Impact of Temperature Variation in North Pacific High over the Indian Monsoon

Gargi Akhoury# and Kirti Avishek*

#CEC, Dept. of Physics, BIT, Mesra, Ranchi
**Dept. of Civil and Environmental Engineering, BIT, Mesra, Ranchi-835215*
*E-mail: #gargiakhoury@bitmesra.ac.in, *kavishek@bitmesra.ac.in*

Abstract—*India is the second most populous country in the world and also the Indian economy is considered as one of the fastest growing major economies. However, climatic disaster is one of the most important factor which hinder the economic progress, further is the cause for majority of people to live in poverty with malnutrition and diseases. The season from June to September is the most important season providing 80% of the annual rainfall which is important from agricultural point of view. As India is the disaster prone area with most being related to water, global warming has become an important factor affecting the climatic condition of India. The researches says that rainfall is a thermal phenomenon, but in spite of increase in temperature, a large ups and down in rainfall can be observed over the subcontinent. The paper discusses the variation in rainfall over the Indian Subcontinent and its relationship with the temperature, outgoing longwave radiation and mean seas level pressure over the North Pacific High. The North Pacific High is considered in the study because during the active Asia-Pacific monsoon, this one of the centres of action which is highly invoked. The period taken in the study is from 1979-2013. The relationship between the Indian rainfall and the various parameters of the North Pacific High are studied with the help of Monte Carlo Method of Correlation and the Bootstrapping method of confidence interval. A good relationship is observed between the rainfall and the defined meteorological parameters of the North Pacific High region. Also, the interannual variability is observed with the help of basic Anomaly method.*

1. INTRODUCTION

India is the second most populous country in the world and also the Indian economy is considered as one of the fastest growing major economies. However, climatic disaster is one of the most important factor which hinder the economic progress, further is the cause for majority of people to live in poverty with malnutrition and diseases. As India is the disaster prone area with most being related to water, global warming has become an important factor affecting the climatic condition of India. **Trenberth (2011)**, analysed that there is a direct influence of global warming on precipitation. Increased heating leads to greater evaporation and thus surface drying, thereby increasing the intensity and duration of drought. However, the water holding capacity of air increases by about 7% per 1°C warming, which leads to increased water vapor in the atmosphere. Hence, storms, whether individual thunderstorms, extratropical rain or snow storms, or tropical cyclones, supplied with increased moisture, produce more intense precipitation events.

Ansell et al. (2000) observed a decadal variability in winter rainfall over various areas in southern Australia and links with the regional mean sea level pressure (MSLP) and sea surface temperature (SST). The dataset used in the study were the GISST 3 and GMSLP 2.1f. More emphasis was put on the southwest Western Australia as this region experienced a significant winter rainfall decline since the mid-1960s. The Cross-spectral, empirical orthogonal function and correlation techniques were used to show the relationship between regional mean sea level pressure and southwest Western Australia rainfall. The principal component analysis and path analysis were used to establish a relationship between the mean sea level pressure sea-surface temperatures with rainfall, also the cause for the decrease in rainfall in southwest Western Australia. The period considered was from 1948 to 2000, **Li et al. (2005).**

Allan et al. (1990), studied with the help of cross correlation between northern Australia sea level and district rainfall anomalies. A strong relationship with El Nino southern oscillation phenomenon over northern and eastern Australia was seen during Austral winter-spring seasons. **Falarz (2009)** analysed a long term changes and the variability of the Icelandic Low and the Azores High in January and their influence on thermal, precipitation and nival conditions in Poland for the period 1901–2000. **Trenberth and Paolino (1980)**, examined a detail description of the Northern Hemisphere monthly mean sea-level grid-point from 1899-1997. They analysed several different aspects of the data that reveal both the problems and real changes in the atmospheric circulation along with a comparison of the monthly mean operational U.S. Navy versus U.S. National Meteorological Center analysis.

Marshall and Harangozo (2000), validated fifty years of monthly mean sea level pressure data from NCEP/NCAR reanalysis against station observations in the extratropical South Pacific and West Antarctica. **Kripalani et al. (1999)**, studied the connection between the Northern Hemisphere lower stratospheric geopotential heights and Indian Monsoon Rainfall (IMR) through the correlation analysis approach. The data used in the study were the monthly grid-point 50hPa geopotential height and the June to September IMR for the period 1958-1990. Analysis reveal that there are domains over the Northern Hemisphere where the variation of the geopotential heights during the preceding months of the monsoon period are related with the interannual behaviour of the IMR. **Lavers et al. (2013)**, links the spatiotemporal variability in gridded European precipitation and large-scale mean sea-level pressure (MSLP) time series (1957–2002) using monthly concurrent correlation to understand the hydroclimatological processes. A strong negative (positive) correlation near Iceland and (the Azores) is apparent for precipitation in northwest Europe, confirming a positive North Atlantic Oscillation (NAO) association.

The western North Pacific subtropical high is a crucial component of the East Asian summer monsoon system and significantly influences the precipitation in East Asia. A research was done on the distinguished role of western North Pacific subtropical high on the East Asian summer monsoon and Indian Ocean monsoon (IOM), **Lee et al. (2013)**. **Rashid et al. (2012)**, approaches the centers of action for the study of summer precipitation (June to August) variability over Europe taking into account variations in the components of the NAO North Atlantic Oscillation (NAO), the Azores High and the Icelandic Low pressure systems. This study shows that north-south shifts of the Azores High has significant impact on interannual variations of summer precipitation over North West Europe. **Schroeder et al. (2013)**, characterizes interannual variability of the North Pacific High over 40 years and investigate how variation in its amplitude and position affect upwelling and biology. The research presents the interannual variation of all India rainfall and the sub-divisional rainfall. The relationship is observed between sub-divisional rainfall and the meteorological parameters of North Pacific high with the help of Monte Carlo method and Bootstrapping method of Confidence interval.

2. DATASETS AND METHODOLOGY

This is an observational analysis based on the monthly rainfall data of all India and four subdivisions which are as Homogeneous India, Central Northeast India, Northeast India and Peninsular India rainfall regions. The monthly geopotential height, mean sea level pressure and tropospheric temperature data was obtained from NOAA NCEP-NCAR CDAS-1. The domain of North Pacific High was taken as 160^{o} W–110^{o} W, 0^{o} –50^{o} N, **Schroeder et al. (2013)**. The packed description of data can be obtained from the site below:

http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP-NCAR/.dataset_documentation.html

The most widespread method to make out the relation between the variables i.e. correlation technique is applied to the variables but with the help of "*Monte Carlo Simulation*". The main theory behind this approach is that a randomly chosen sample tends to exhibit the same properties as the population from which it is drawn, **(Raychaudhuri 2008)**. For the Monte Carlo method of correlation, the random numbers were generated from a normal distribution with the help of mean and standard deviation of our data, with reference to **(Raychaudhuri 2008)**. A confidence interval was set up for the data and it was estimated by the method known as "*Bootstrapping*". It is often assumed to make more sense than testing a null hypothesis, **(Wood 2004)**. Also, the method Bootstrap confidence interval has a number of advantages over conventional methods which are thoroughly explained in, **(Wood 2004)**.

3. RESULT & DISCUSSION

Abbreviations:

AIR-All India Rainfall, HIR- Homogenous India Rainfall, CNEIR- Central Northeast India Rainfall, NEIR- Northeast India Rainfall, PIR- Peninsular India Rainfall, MSLP- Mean Sea Level Pressure, GpH- Geopotential Height, LTT- Lower Tropospheric Temperature, MTT- Middle Tropospheric Temperature, UTT- Upper Tropospheric Temperature, WTT- Whole Tropospheric Temperature

Table 1: Climatological and fluctuation features of monthly rainfall of subdivision of India

Months / Regions	May	June	July	August	September	October
AIR	533.23 ±161.95	1602.63 ±335.45	2678.40 ±371.45	2445.23 ±311.91	1693.80 ±358.09	811.62 ±288.32
HIR	180.08 ±124.34	1250.08 ±396.67	2524.82 ±551.14	2305.03 ±482.67	1422.66 ±543.57	437.98 ±277.54
CNEIR	439.71 ±231.86	1605.46 ±631.72	3075.89 ±557.16	3034.69 ±489.77	2086.29 ±476.83	742.83 ±519.40
NEIR	2281.86 ±548.95	3631.05 ±721.26	3995.80 ±772.79	3396.35 ±540.60	2766.95 ±622.54	1452.03 ±638.96
PIR	871.55 ±444.08	1645.32 ±392.09	1921.77 ±437.62	1613.71 ±395.57	1515.72 ±471.56	1860.74 ±565.70

The Table shows the mean and the standard deviation of monthly rainfall of the eight sub regions of India for the months from May to October. The highest rainfall month for All India rainfall region are from June to September. The maximum deviation from mean rainfall can be seen in the month of July and then in September of ±371.45 and ±358.09 respectively. The highest rainfall are in the months of July and August of 2678.40 and 2445.23 respectively. The minimum rainfall is seen in the month of May of 533.23 mm. The maximum rainfall month is July 2524.82 for the Homogeneous India rainfall and the lowest rainfall month is the May with 180.08mm. For the Central North East India rainfall July, August and September are rainiest month, the highest rainfall in July 3075.89mm and the lowest in May of about 439.71mm. The month October shows the large deviation from the mean rainfall. The North East India rainfall region receives the highest rainfall among all the subdivisions in all the months from May to October. The highest rainfall is observed in the month of July of 3995.80mm and the lowest rainfall is received during the October month of 1452.03mm. The highest rainfall month for the Peninsular India rainfall region is July of 1921.77mm and the lowest rainfall is received during the month May of 871.55mm.

Tables 2 and 3 shows the climatological and fluctuation features of MSLP, GpH, Tropospheric thickness and temperature of the North Pacific High region.

Table 2: Climatological and fluctuation features of MSLP, GpH and Tropospheric Thickness of NPH

Months / Regions	May	June	July	August	September	October
MSLP	1015.68 ±0.82	1015.62 ±0.69	1015.91 ±0.48	1015.54 ±0.57	1014.67 ±0.68	1014.87 ±0.70
GpH-LT	1393.06 ±6.35	1399.89 ±5.67	1408.04 ±3.97	1406.10 ±4.50	1396.15 ±5.39	1391.46 ±5.66
GpH-MT	5084.22 ±8.57	5112.88 ±7.43	5132.05 ±7.44	5131.20 ±7.01	5115.03 ±7.41	5092.36 ±8.53
GpH-UT	9273.02 ±13.60	9329.98 ±12.00	9362.25 ±13.89	9364.50 ±12.12	9344.61 ±12.53	9298.04 ±14.65
Tropospheric Thickness	10650.94 ±16.63	10717.28 ±14.69	10751.40 ±17.03	10757.76 ±15.04	10744.00 ±15.73	10687.82 ±17.57

Table 3. Climatological and fluctuation features of Tropospheric Temperature of NPH

Months / Regions	May	June	July	August	September	October
LTT	12.99 ±0.46	14.48 ±0.37	15.62 ±0.40	15.86 ±0.39	15.34 ±0.40	14.01 ±0.46
MTT	-5.53 ±0.45	-3.85 ±0.36	-3.17 ±0.40	-2.97 ±0.36	-3.16 ±0.36	-4.51 ±0.42
UTT	-34.19 ±0.48	-28.76 ±0.40	-31.91 ±0.52	-31.75 ±0.46	-31.96 ±0.45	-33.30 ±0.48
WTT	-6.85 ±0.39	-4.01 ±0.32	-4.40 ±0.39	-4.20 ±0.35	-4.54 ±0.38	-5.87 ±0.43

Table 4 shows the Monte Carlo correlation & Bootstrap Confidence Interval of Monthly sub-divisional Rainfall and tropospheric Temperature of North Pacific High.

Table 4: Monte Carlo correlation & Bootstrap Confidence Interval of Monthly sub-divisional Rainfall and tropospheric Temperature of NPH.

Levels	Correlation Coefficient with Trop Temp NPH AIR					
	May	**June**	**July**	**Aug**	**Sept**	**Oct**
LTT	0 [-0.22 0.24]	0.33 [-0.20 0.34]	-0.37 [-0.37 0.21]	-0.45 [-0.46 -0.02]	-0.51 [-0.51 -0.13]	-0.44 [-0.47 0.06]
MTT	0.38 [-0.09 0.38]	-0.30 [-0.33 0.22]	-0.34 [-0.36 0.19]	-0.32 [-0.32 0.15]	0 [-0.23 0.24]	0.31 [-0.28 0.35]

ISBN-978-93-85822-49-0

UTT	0.35 [-0.13 0.35]	-0.41 [-0.42 0.16]	-0.34 [-0.34 0.12]	-0.35 [-0.35 0.07]	-0.32 [-0.32 0.17]	-0.35 [-0.35 0.19]
WTT	0.33 [-0.15 0.33]	-0.28 [-0.30 0.25]	-0.37 [-0.37 0.14]	-0.44 [-0.44 0.06]	-0.40 [-0.40 0.07]	-0.38 [-0.39 0.16]
Levels	**Correlation Coefficient with Trop Temp NPH HIR**					
	May	**June**	**July**	**Aug**	**Sept**	**Oct**
LTT	-0.21 [-0.23 0.18]	0.38 [-0.14 0.39]	-0.31 [-0.35 0.27]	-0.43 [-0.43 0.04]	-0.50 [-0.50 -0.10]	-0.50 [-0.50 0.01]
MTT	0.28 [-0.12 0.29]	0 [-0.28 0.27]	-0.30 [-0.31 0.22]	-0.24 [-0.26 0.19]	0 [-0.23 0.24]	0 [-0.29 0.30]
UTT	0.24 [-0.22 0.29]	-0.26 [-0.30 0.21]	-0.38 [-0.38 0.15]	-0.32 [-0.32 0.12]	-0.28 [-0.29 0.20]	-0.38 [-0.38 0.19]
WTT	0 [-0.24 0.25]	0.24 [-0.23 0.29]	-0.34 [-0.35 0.17]	-0.37 [-0.37 0.09]	-0.37 [-0.37 0.06]	-0.42 [-0.42 0.12]
Levels	**Correlation Coefficient with Trop Temp NPH CNEIR**					
	May	**June**	**July**	**Aug**	**Sept**	**Oct**
LTT	0.32 [-0.10 0.32]	0.24 [-0.25 0.28]	0.24 [-0.24 0.28]	-0.37 [-0.37 0.05]	-0.35 [-0.35 0.15]	-0.45 [-0.45 0.09]
MTT	0.38 [-0.08 0.38]	-0.33 [-0.34 0.17]	-0.26 [-0.27 0.17]	-0.45 [-0.45 0.07]	-0.27 [-0.32 0.29]	0.34 [-0.22 0.37]
UTT	0.34 [-0.12 0.34]	-0.46 [-0.46 0.05]	0.22 [-0.17 0.23]	-0.41 [-0.41 0.02]	-0.33 [-0.34 0.18]	-0.33 [-0.33 0.18]
WTT	0.34 [-0.08 0.34]	-0.34 [-0.35 0.17]	0.21 [-0.21 0.24]	-0.42 [-0.42 0.03]	-0.33 [-0.34 0.18]	-0.36 [-0.37 0.18]
Levels	**Correlation Coefficient with Trop Temp NPH NEIR**					
	May	**June**	**July**	**Aug**	**Sept**	**Oct**
LTT	0.18 [-0.16 0.20]	-0.53 [-0.53 -0.09]	-0.46 [-0.46 0.02]	-0.36 [-0.36 0.10]	0.22 [-0.19 0.24]	0.22 [-0.19 0.25]
MTT	0.29 [-0.10 0.30]	-0.48 [-0.48 -0.08]	-0.30 [-0.34 0.23]	-0.25 [-0.27 0.19]	-0.23 [-0.28 0.24]	0.41 [-0.08 0.41]
UTT	0.31 [-0.12 0.31]	-0.47 [-0.47 -0.03]	-0.29 [-0.32 0.24]	-0.24 [-0.29 0.23]	-0.22 [-0.26 0.18]	0 [-0.24 0.24]
WTT	0.24 [-0.12 0.25]	-0.54 [-0.54 -0.12]	-0.39 [-0.39 0.13]	-0.33 [-0.33 0.17]	-0.21 [-0.24 0.21]	0.24 [-0.18 0.28]

Levels	Correlation Coefficient with Trop Temp NPH PIR					
	May	June	July	Aug	Sept	Oct
LTT	-0.30 [-0.33 0.22]	0.45 [-0.03 0.45]	-0.39 [-0.39 0.09]	-0.34 [-0.34 0.12]	-0.37 [-0.37 0.08]	-0.31 [-0.31 0.14]
MTT	0.33 [-0.16 0.34]	0.41 [-0.07 0.41]	-0.37 [-0.38 0.12]	-0.21 [-0.25 0.22]	0.24 [-0.25 0.28]	-0.30 [-0.31 0.16]
UTT	0.36 [-0.14 0.37]	0.40 [-0.09 0.40]	-0.36 [-0.37 0.15]	0.21 [-0.22 0.24]	0 [-0.27 0.28]	-0.20 [-0.26 0.24]
WTT	0.27 [-0.23 0.30]	0.45 [-0.03 0.45]	-0.38 [-0.39 0.10]	-0.25 [-0.26 0.16]	-0.33 [-0.33 0.18]	-0.30 [-0.31 0.15]

Table 5: Monte Carlo correlation & Bootstrap Confidence Interval of Monthly sub-divisional Rainfall with MSLP and tropospheric thickness of NPH.

	Correlation Coefficient with MSLP NPH					
	May	June	July	Aug	Sept	Oct
AIR	0.22 [-0.19 0.23]	0.42 [0.06 0.44]	0.39 [-0.05 0.39]	0.48 [0.08 0.49]	0.59 [0.24 0.59]	0.57 [0.11 0.58]
HIR	0.22 [-0.15 0.23]	0.45 [0.06 0.45]	0.43 [-0.02 0.43]	0.46 [0.06 0.46]	0.51 [0.18 0.51]	0.57 [0.16 0.58]
CNEIR	0.32 [-0.13 0.33]	0.44 [0.06 0.45]	-0.23 [-0.24 0.18]	0.36 [-0.14 0.36]	0.49 [0.05 0.49]	0.45 [-0.02 0.47]
NEIR	-0.28 [-0.30 0.17]	-0.28 [-0.29 0.16]	-0.33 [-0.33 0.24]	-0.30 [-0.31 0.11]	0.34 [-0.08 0.34]	0.26 [-0.20 0.29]
PIR	0 [-0.24 0.22]	0.24 [-0.19 0.25]	0.35 [-0.15 0.35]	0.47 [0.02 0.48]	0.40 [-0.09 0.40]	0.41 [-0.02 0.42]
	Correlation Coefficient with Trop Thickness NPH					
	May	**June**	**July**	**Aug**	**Sept**	**Oct**
AIR	0.33 [-0.11 0.35]	-0.32 [-0.33 0.24]	-0.34 [-0.37 0.16]	-0.38 [-0.40 0.07]	-0.30 [-0.33 0.14]	-0.34 [-0.36 0.21]
HIR	0.27 [-0.19 0.27]	0.28 [-0.26 0.29]	-0.33 [-0.35 0.21]	-0.34 [-0.35 0.13]	-0.30 [-0.32 0.15]	-0.38 [-0.38 0.19]
CNEIR	0.36 [-0.05 0.36]	-0.35 [-0.36 0.11]	0 [-0.21 0.21]	-0.44 [-0.44 0.04]	-0.33 [-0.34 0.21]	-0.29 [-0.30 0.24]

NEIR	0.25 [-0.11 0.26]	-0.51 [-0.52 - 0.11]	-0.38 [-0.38 0.18]	-0.29 [-0.30 0.18]	-0.22 [-0.25 0.20]	0.30 [-0.18 0.31]
PIR	0.32 [-0.18 0.32]	0.45 [-0.06 0.45]	-0.40 [-0.40 0.09]	-0.23 [-0.25 0.19]	-0.30 [-0.30 0.20]	-0.29 [-0.29 0.20]

4. CONCLUSIONS

During the monsoonal months June, July, August and September the rainfall regions AIR, HIR, CNEIR, NEIR and PIR regions shows a very good negative correlation with the LTT, MTT, UTT and WTT. The pre-monsoon month May show a positive correlation between rainfall of all the sub divisions and the tropospheric temperature of the North Pacific High at all the level, LTT, MTT, UTT and WTT. A very good positive correlation is seen between the sub-divisional rainfall regions AIR, HIR and PIR with MSLP of North Pacific High whereas the sub-divisional rainfall region NEIR show good negative correlation with the North Pacific High from May to August and CNEIR shows a good positive correlation with MSLP in all the months except July. A good negative correlation is observed between rainfall of all the subdivisions and the tropospheric thickness of NPH from the months June to October except the July month in the region CNEIR which doesn’t show any relationship. Thus, it is observed widely that a relationship exists between the sub-divisional rainfall regions and tropospheric temperature, MSLP, and tropospheric thickness. The result is seemed to be perfect by taking these parameters of NPH i.e. tropospheric temperature, MSLP and tropospheric thickness. It will be more accurate if more parameters and regions are added to the analysis and compare it with Indian rainfall variability. The researchers want to extrapolate the findings and the analysis report in a more improvised way to review and analyse the variability of Indian Monsoon.

5. ACKNOWLEDGMENTS

We thank IRI Data Library which is a powerful and freely accessible online data repository and helps the user to view, download and analyse the reanalysis climate data. We are very thankful to Indian Meteorological Department for providing us the Rainfall data. We thank Dr. Ashwini Ranade for her support and guidance. A big thank to Dr. Gnanseelan for his motivation. We would also like to thank the Department of Physics and the Department of Civil and Environmental and Engineering, B.I.T, Mesra, Ranchi for this cooperation.

REFERENCES

[1] Trenberth Kevin E., Changes in precipitation with climate change, Climate Research, March 31, 2011, doi: 10.3354/cr00953

[2] Ansell T.J., C.J.C Reason, I.N. Smith and K. Keay, Evidence for Decadal Variability in Southern Australian Rainfall and Relationships with Regional Pressure and Sea Surface Temperature, International Journal of Climatology, 20: 1113–1129 (2000)

[3] Li Fuqin, Lynda E. Chambers and Neville Nicholls, Relationships between rainfall in the southwest of Western Australia and near-global patterns of sea-surface temperature and mean sea-level pressure variability, Aust*. Met. Mag.* 54 (2005) 23-33

[4] Allan Robert J., Karen Beck and William M. Mitchell, Sea Level and Rainfall Correlations in Australia: Tropical Links. Journal of Climate, Volume 3, February 1990.

[5] Falarz Małgorzata, Variability of The Icelandic Low and The Azores High in January and their Influence on Climatic Conditions In Poland, Bulletin of Geography – physical geography series, No 2/2009: 5–18

[6] Trenberth Kevin E. and Daniel A. Paolino, Jr, The Northern Hemisphere Sea-Level Pressure Data Set: Trends, Errors and Discontinuities. Monthly Weather Review, Volume 108, February 1980.

[7] Marshall Gareth J. and Stephen A. Harangozo, An appraisal of NCEP/NCAR reanalysis MSLP data viability for climate studies in the South Pacific, Geophysical Research Letters Vol. 27, No. 19, Pages 3 057-3060 October, 2000

[8] Kripalani R. H., A. Kulkarni, S. R. Inamdar, and K. D. Prasad, Teleconnections: Northern Hemisphere Lower Stratospheric Geopotential Heights and Indian Monsoon Rainfall, Meteorol. Atmos. Phys. 69, 195-203 (1999)

[9] Lavers David, Christel Prudhomme and David M. Hannah, European precipitation connections with large-scale mean sea-level pressure (MSLP) fields, *Hydrological Sciences Journal*, 58 (2), 310–327, http://dx.doi.org/10.1080/02626667.2012.754545

[10] Lee Sun-Seon, Ye-Won Seo, Kyung-Ja Ha, and Jong-Ghap Jhun, Impact of the Western North Pacific Subtropical High on the East Asian Monsoon Precipitation and the Indian Ocean Precipitation in the Boreal Summertime, Asia-Pacific J. Atmos. Sci., 49(2), 171-182, 2013, doi:10.1007/s13143-013-0018-x

[11] Rashid Shahnaz Ali, Muhammad Jawed Iqbal, Muhammad Arif Hussain, Impact of North-South Shift of Azores High on Summer Precipitation over North West Europe, *International Journal of Geosciences*, 2012, 3, 992-999, http://dx.doi.org/10.4236/ijg.2012.325099 Published Online October 2012 (http://www.SciRP.org/journal/ijg)

[12] Schroeder Isaac D., Bryan A. Black, William J. Sydeman, Steven J. Bograd, Elliott L. Hazen, Jarrod A. Santora, and Brian K. Wells, The North Pacific High and wintertime pre-conditioning of California current productivity, Geophysical Research Letters, Vol. 40, 541–546, doi:10.1002/grl.50100, 2013

[13] Raychaudhuri Samik, Introduction To Monte Carlo Simulation. Proceedings of the 2008 Winter Simulation Conference, S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, J. W. Fowler eds., 2008.

[14] Wood Michael, Statistical inference using bootstrap confidence intervals. Significance, Vol. 1, No 4. 2004, link: http://onlinelibrary.wiley.com/doi/10.1111/j.1740-9713.2004.00067.x/pdf.