INDIAN CENTRE FOR CLIMATE AND SOCIETAL IMPACTS RESEARCH (ICCSIR)

Annual Report 2016 - 2017

Dr. Rohit Srivastava [1], Ph.D.

Assistant Professor

Indian Centre for Climate and Societal Impacts Research,

Sri Vivekanand Research & Training Institute (VRTI) Campus,

Nagalpur Road,

Mandvi, Kachchh,

Gujarat, India.

Phone No. +91 - 2834 - 224024 & Fax: +91 - 2834 - 224024

Web: http://www.iccsir.org

Corporate Identity Number (CIN) : U73100GJ2008NPL054708

---

[1]rohit.srivastava@iccsir.org

Vision

An integrated, multidisciplinary approach to research in the science of climate evolution and in societal adaptation to climate evolution is necessary for socio-economic and political stability of the global society in the 21st century.

Goals

Research Goals : Development of methodologies for assessment of climate variability and changes in western India at sub-seasonal to decadal time scales due to natural variability and human-induced changes, including global warming, and their societal impacts, using observations and models. Understanding of climate related societal issues by means of inter-disciplinary (both at national and international levels) association; and development of techniques and technology for Earth System observations and modeling.

Education Goals : Education and training programs for high-school to post-graduate college teachers, public and private sector officials, on Earth System Science (ESS) and societal impacts of climate variability and changes, including global warming. Ph.D. program for education and research in ESS and societal impacts.

Applications and Outreach Goals : Generate ESS and societal impacts data and information systems for farmers, water managers, public health officials, other stakeholders, and policymakers.

Create public awareness to these issues through exhibition-cum-experiments laboratory, and video and TV programs.

Board of Directors

Shri J. S. Gosalia	Excel Industries, Mumbai and Trusty VRTI
Shri D. B. Mehta	Excel Industries, Mumbai
Shri Khushalbhai Bhanani	Manager, Agrocel Industries Ltd., Bhuj
Dr. Yogesh Jadeja	Director, Arid Communities and Technologies, Bhuj

Faculty & Staff

Dr. Rohit Srivastava	Assistant Professor
Mr. Shouvik Jha	Research Assistant
Mr. Sherin Hassan Bran	Senior Research Fellow (Left ICCSIR during February, 2017)
Ms. Pruthvi Patel	Technical Assistant

2

Contents

Chapter 1

Research Activities

This part of report contains the scientific research activities carried out from April, 2015 to March 2016. Presently, ICCSIR is involved in two scientific projects details given below :

- Project title : "South Asian Precipitation: A Seamless Assessment: SAPRISE"
  Funding agency : Ministry of Earth Sciences, Govt. of India under the Indo-UK Changing Water Cycle Programme (Completed on 31 July, 2016).

- Project title : "Investigation of the role of black carbon on aerosol radiative forcing over western India"
  Funding agency : Department of Science and Technology (DST), Govt. of India. (Completed on 20 January, 2017)

- Project title : "Use of GIS in Rukmavati River Basin for sustainable agriculture",
  Funding Agency : Shroff Family Charitable Trust (SFCT), Mumbai.

1.1 Investigation of $PM_{2.5}$ mass concentration over India

Sherin H. Bran and Rohit Srivastava

Seasonal variation of $PM_{2.5}$ (Particulate Matter < 2.5 μm) mass concentration simulated from WRF-Chem (Weather Research and Forecasting coupled with Chemistry) over Indian sub-continent are studied. The simulated $PM_{2.5}$ are also compared with the observations during winter, pre-monsoon, monsoon and post-monsoon seasons of 2008. Higher value of simulated $PM_{2.5}$ is observed during winter followed by post-monsoon, while lower values are found during monsoon. Indo-Gangetic Basin (IGB) exhibits high amount of $PM_{2.5}$ (60 - 200 μg m^{-3}) throughout the year (Figure 1.1. The percentage differences between model simulated and observed $PM_{2.5}$ are found higher (40 - 60%) during winter, while lower ($< 30\%$) during pre-monsoon and monsoon over most of the study locations.
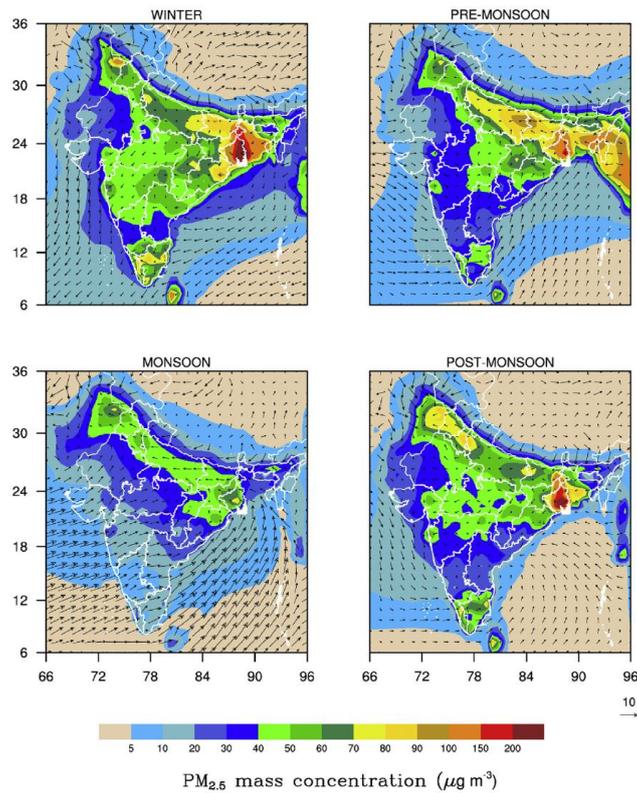

Figure 1.1: Spatial and seasonal distribution of PM2.5 mass concentration during winter, pre-monsoon, monsoon and post-monsoon at surface level on 2008.

The weighted correlation coefficient between model simulated and observed $PM_{2.5}$ is 0.81 at the significance of 98%. Associated RMSE (Root Mean Square Error) is 0.91 μg m^{-3} . Large variability in vertically distributed $PM_{2.5}$ are also found during pre-monsoon and monsoon.

The study reveals that, model is able to capture the variabilities in spatial, seasonal and vertical distributions of $PM_{2.5}$ over Indian region, however significant bias is observed in the model. $PM_{2.5}$ mass concentrations are highest over West Bengal (82 μg m^{-3}) and the lowest in Jammu & Kashmir (14 μg m^{-3}). Annual mean of simulated $PM_{2.5}$ mass over the Indian region is found to be 35 μg m^{-3}. Higher values of $PM_{2.5}$ are found over the states, where the reported respiratory disorders are high. WRF-Chem simulated $PM_{2.5}$ mass concentration gives a clear perspective of seasonal and spatial distribution of fine aerosols over the Indian region. The outcomes of the study have significant impacts on environment, human health and climate.

1.2 Investigation of an intense dust storm event over the Arabian sea

Sherin Hassan Bran and Rohit Srivastava

Dust aerosols are the second largest sources of natural aerosols and have significant potential to influence the climate feedback. An intense dust storm event occurred during 17 – 24 March, 2012 over the Middle East region and transported over AS. Aerosol optical and radiative properties are simulated using Weather Research and Forecasting model coupled with Chemistry (WRF-Chem). The simulations are performed over the region of the Arabian Sea (AS) extended from 50^0E to 80^0E longitude and 10^0N to 30^0N latitude at horizontal resolution of 50 km with 29 vertical levels. Morrison double moment scheme for microphysics, radiation process by Rapid Radiative Transfer Model for General circulation models (RRTMG) and for chemical process Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) are utilized in the WRF-CHEM simulation.

Spatial distribution of mid-visible AOD simulated from WRF-Chem and obtained from MODIS and MISR during normal day (19 March, 2012) and storm day (21 March, 2012) over the Arabian Sea is shown in Figure 1.2. Correlation coefficient between simulated and MODIS retrieved AOD is found to be 0.54, while low correlation (0.32) is found for MISR. The root mean square error (RMSE) is of the order ~ 51 and $\sim 57\%$ with respect to MODIS and MISR respectively. Model simulated AOD on dusty day (21 March 2012) was found to be increased by 2 to 3 times of the AOD during non-dusty days (19 March 2012).
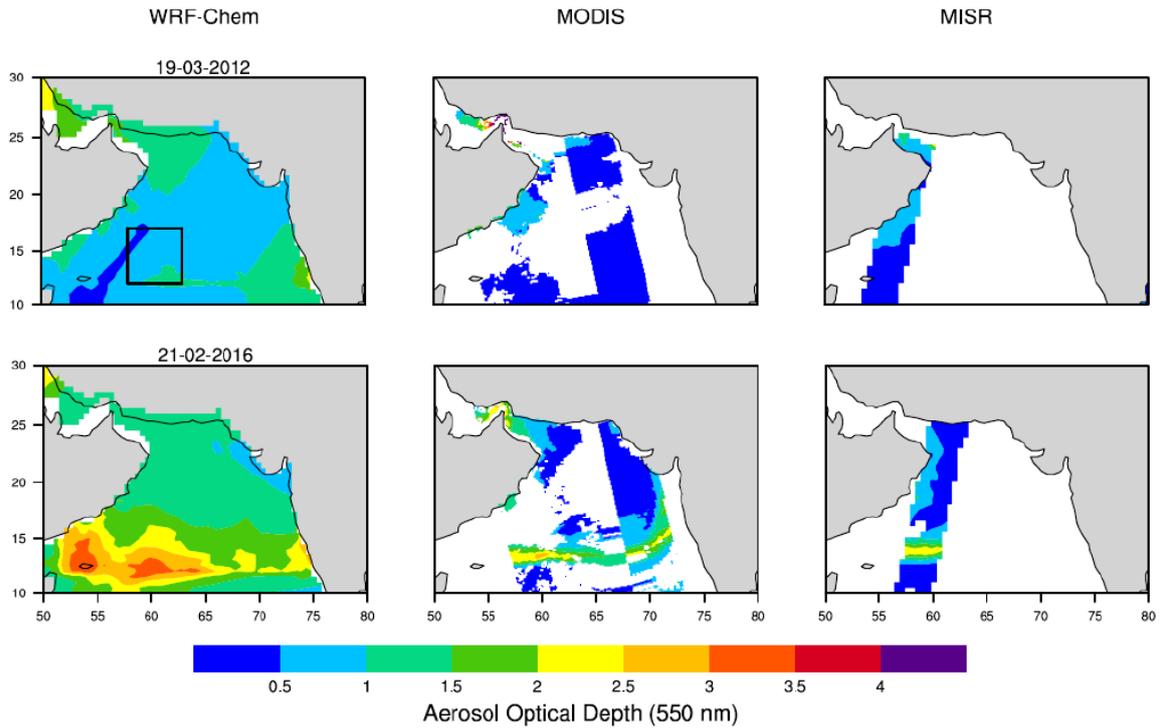
Figure 1.2: Spatial distribution of mid-visible (0.55 μm) AOD simulated from WRF-Chem and retrieved from MODIS and MISR during the normal and dust storm days (19 and 21 March, 2012) over the Arabian Sea.

WRF-Chem showed an overestimation (40 to 60%) in simulated AODs when compared to the satellite measurements. However, simulation captures the spatial variations in AOD during the event. The single scattering albedo (SSA) and the asymmetry parameter have increased by 0.96 to 0.99 and 0.56 to 0.66, respectively during the event. The difference between the model simulated and NCEP reanalysis wind speeds are found to be within 30% at the pressure level of 850 hPa, while the wind direction lies within 10%. The short wave aerosol radiative forcing at surface during dust storm is $\sim$ 2 - 5 times higher than normal days and aerosol heating rate during dusty days is found to increased from 0.2 to 0.4 K day^{-1}.

1.3 An assessment of water storage in the reservoir using satellite remote sensing

Kajal Barman†, Shouvik Jha and Rohit Srivastava

The satellite remote sensing can be a useful tool for investigating water availability in the water reservoirs. The continuous measurement from satellite remote sensing allows estimating over large areas within very short time and greater accuracy and in inaccessible areas. The study has utilized remote sensing (RS) satellite data and developed an approach to investigate the water status in the water reservoir and it is a cost-effective method. The remote sensing approach is used to study the water availability in Rihand Dam (Govind Ballabh Pant Sagar) in Pipri, Sonbhadra, Uttar Pradesh, India from 2002 – 2016 (Figure 1.3).
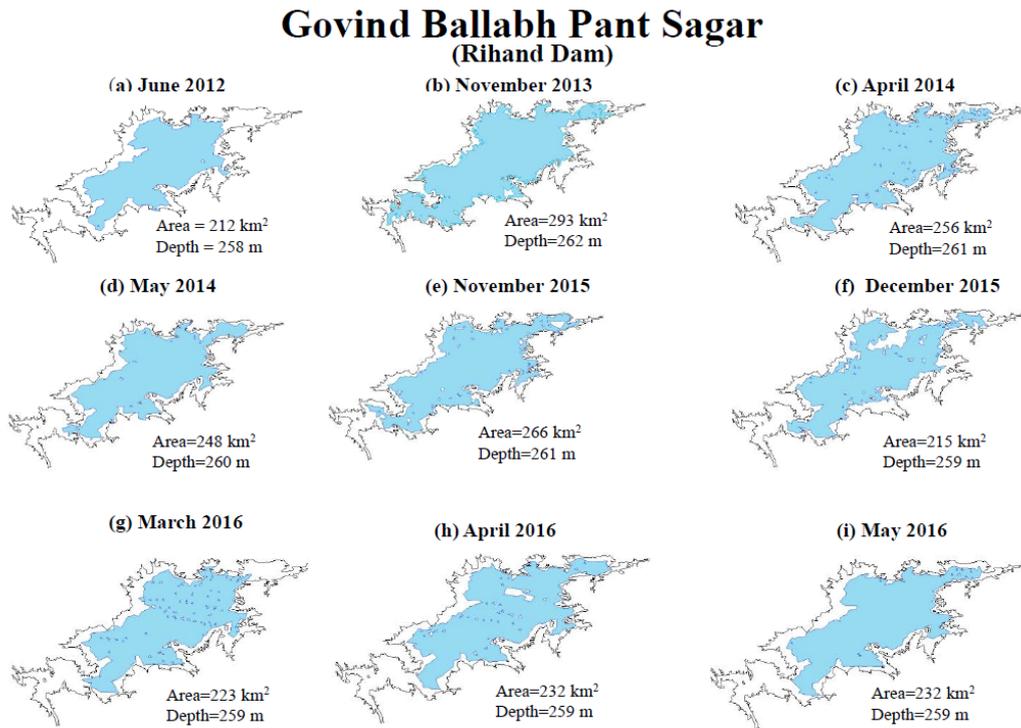

Figure 1.3: Status of water in Govind Ballabh Pant Sagar in different months from 2013 - 2016

In the present study, the Radar Altimetry and MODIS (Moderate Resolution Imaging Spectrometer) data are utilized. MODIS NDVI (Normalized Difference Vegetation Index) data (MOD13Q1) are used to calculate the water surface area.

MOD13Q1 has a horizontal resolution of 250 meters and temporally available at 16 days interval. A relationship between Radar altimetry depth (D) and MOD13Q1 estimated water surface area (A) is developed from 2002 - 2010. The estimated depths are validated with the reservoir depth measured by CWC (Central Water Commission), India. The correlation between the remote sensing estimated water depth and CWC measured water depth is found to be 0.82. The root mean square difference between estimated and measured depth is 2 m which is about 1% of the average water depth of the reservoir. The surface area in June 2012 was the lowest (212 km^2), while highest (293 km^2) in November 2013 (Figure 1.3). The water level in the reservoir was found to be lower in post-monsoon season of 2015 when compared to that of 2014.

Thus, the satellite measurements of water reservoir can be a good approach for monitoring the water reservoirs. The continuous monitoring of water availability in the reservoir will mainly be helpful for planning irrigation, hydropower, controlling flood and managing water during the drought period.

† *Kajal Barman was M.Sc. student. He did his M.Sc. dissertation under supervision of Dr. Rohit Srivastava*

1.4 A quantitative Assessment of Terrestrial Vegetation Carbon Storage using Remote Sensing Approach over Gujarat, India

Shouvik Jha and Rohit Srivastava

The continuous increasing trend (350 ppm to 407 ppm for the year of 2000 –2016) of carbon dioxide (CO_2) is very serious problem in front of global community. Agro-Ecosystem plays a vital role in global carbon balance. Net primary productivity (NPP) or vegetation carbon storage (VCS) represent the fixation of carbon in vegetation from the atmosphere over a period of time. It is necessary to quantify carbon sequestration by green cover in global as well as regional perspective. The present study investigates the spatio-temporal variability of VCS over the Gujarat, India during 2012 using production efficiency based CASA (Carnegie Ames Stanford Approach) model. Vegetation cover and meteorological parameters are also one of the major drivers into the model calculation. VSG is calculated from Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI data and meteorology data e.g. temperature, solar radiation etc from Modern Era Retrospective-Analysis for Research and Applications (MERRA). The deciduous broadleaf forest is found to have the maximum strength to sequestrate carbon over the region which is about 92 g C m^2Yr^{-1} followed by mixed forest (90 g C m^2Yr^{-1}), crop land (64 g C m^2Yr^{-1}), shrub land (47 g C m^2Yr^{-1}), grass land (18 g C m^2Yr^{-1}). The mean VCS over Gujarat is found to be 52 g C m^2Yr^{-1} with highest rate of VCS (71 g C m^2Yr^{-1}) during October. The study is useful in monitoring and managing natural resources with help remote sensing and GIS.

Chapter 2

Application and outreach activities

ICCSIR is involved in different outreach activities.

2.1 ICCSIR's weekly weather forecast bulletin

ICCSIR is releasing weekly weather forecast bulletin based on publicly available data and maps. The bulletin contains the spatial map of daily rainfall forecast over India and surrounding regions. The rainfall maps are generated from NCM-RWF's Global Forecast System (NGFS) model for 6 days forecast. 5 day forecast of weather parameter (rainfall, maximum and minimum temperature, total cloud cover, maximum and minimum relative humidity, wind speed and directions) over district centers of Gujarat and Maharashtra are provided in tabular form.

ICCSIR's weather bulletin was found to very helpful for farmers, social workers etc.

2.2 Dissemination of current weather data

The current morning and afternoon weather data have been recorded from the meteorological observatory installed at VRTI campus, Mandvi, Kachchh. The data are being disseminated to the farmers and para-workers of the region on each day.

2.3 Dissemination of Long Range Weather forecast

ICCSIR provided the Long-range weather forecast of Southwest Monsoon 2015 based on the India Meteorological Department (IMD) and World Meteorological Organization (WMO) and other forecasting agencies during April and June 2016. In the forecast, normal rainfall during monsoon 2016 was predicted over western Indian region which found to be correct over the Gujarat and Maharashtra region. This long-range forecast was very useful in planning different agricultural activities.

2.4 Satellite image over Agrocel Marine Chemical Division (MCD) at Dhordo, Kachchh

The satellite images of Dhordo area were obtained from Landsat 8 at a interval of 2 weeks. The raw images were processed and the images of horizontal resolution of 15 m were generated over the area of interest. These processed images is very useful in planning different activities at MCD, Agrocel Industries Ltd., Dhordo, Kachchh.

2.5 Training Programme

ICCSIR is involved in different farmers training program. ICCSIR provided the training on role of weather and climate on agriculture. ICCSIR also provided training on role of farmer in mitigating the climate change. Weather forecasts and its utilization for sustainable agriculture. ICCSIR also participated Farmer Training Workshop for Sustainable Agriculture organized by National Centre for Sustainable Development (NCCSD). This workshop was organized at different regions of Gujarat.

Chapter 3

Educational activities

ICCSIR participated in different educational activities in different places in India,

- ICCSIR staffs provided lectures on different courses on Environmental Science and Marine Science at Graduate level in Government Science College, Mandvi, Kutch.

- ICCSIR has participated in finalizing the content of different exhibitions on Climate Change in Science Express Climate Action Special (SE-CAS). ICCSIR is one of the knowledge partners of Centre for Environment Education (CEE) during the designing of SE-CAS.

- ICCSIR was involved in delivering lectures to students of different school/colleges on Weather and Climate.

Chapter 4

Research Publication and participation in conferences

ICCSIR published its research outcomes in various reputed Journal and conference proceedings :

- Investigation of PM2.5 mass concentration over India using a regional climate model,
  Authors : S. H. Bran, and Rohit Srivastava
  Journal : Environmental Pollution, 224, 484–493, 2017.

- Investigation of an intense dust storm event over Arabian sea, Sherin Hassan Bran, S. Jose, and Rohit Srivastava, Indian Aerosol Science and Technology Association Bulletin, 22, (1–2), ISSN: 0971-4510, 317–319, 2016.

ICCSIR participated in various Conferences/Seminars/Workshops such as:

- Invited presentation entitled "Weather forecasting for Sustainable Agriculture", at United Nation (UN) Climate Change Conference (COP - 22), on November 09, 2016 at Marrakech, Morocco.

- Invited presentation entitled "Role of weather forecasting in arena of Climate change", at International Conference on Food, Water, Energy Nexus in Arena of Climate Change, during December 14 - 16, 2016 at Anand Agricultural University (AAU), Anand, Gujarat, India.

- Poster presentation entitled "Aerosol (PM2.5) mass concentration over the Indian subcontinent", at National Symposium on Tropical Meteorology (TROP-MET) - 2016, during December 18 - 21, 2016 at Siksha O' Anusandhan University, Bhubaneswar, Odisha, India.

- ICCSIR participated in Leadership Training programme of Farmers at Gajera, Jambusar, Bharuch organized by Aatapi Seva Foundation.

Chapter 5

Summary and Future plan

5.1 Summary

ICCSIR was involved on different research, outreach, training and education activities during 2016 -2017.

The major research finding during year 2016 - 2017 were as follows :

- Higher value of simulated $_{2.5}$ is observed during winter (December - February) followed by post-monsoon (October - November), while lower values are found during monsoon (June - September). Indo-Gangetic Basin (IGB) exhibits high amount of PM2.5 (60 - 200 μg m^{-3}) throughout the year.

- PM$_{2.5}$ mass concentrations are highest over West Bengal (82 μg m^{-3}) and the lowest in Jammu & Kashmir (14 μg m^{-3}). Annual mean of simulated $_{2.5}$ mass over the Indian region is found to be 35 μg m^{-3}. Higher values of $_{2.5}$ are found over the states, where the reported respiratory disorders are high.

- Regional climate model simulated AOD on dusty day (21 March 2012) was found to be increased by 2 to 3 times of the AOD during non-dusty days (19 March 2012). The short wave aerosol radiative forcing at surface during dust storm is $\sim$ 2 - 5 times higher than normal days and aerosol heating rate during dusty days is found to increased from 0.2 to 0.4 K day^1 .

- The correlation between the remote sensing estimated water depth and CWC (Central Water Commission, India) measured water depth is found to be 0.82. The root mean square difference between estimated and measured depth is 2 m which is about 1% of the average water depth of the reservoir. The surface area

in June 2012 was the lowest (212 km^2), while highest (293 km^2) in November 2013.

ICCSIR was involved in different education and outreach activities :

- Dissemination of ICCSIR's weekly weather forecasts on each Tuesday of the week.

- Dissemination of daily current weather data to para-workers and farmers in Rukmavati River basin region.

- ICCSIR was providing high resolution satellite imagery over Dhordo Kutch to Marine Chemical Division of Agrocel Industries Ltd.

- ICCSIR was involved in different Training programmes on weather and agriculture.

- ICCSIR's staffs were also involved in educating graduate students of Government Science College, Mandvi, Kutch on Environmental and Marine Sciences.

5.2   Future Plan

ICCSIR will continue its education and outreach activities and participate in different training programs.

- Research on Southwest Indian monsoon and optical and radiative properties of atmospheric aerosols.

- ICCSIR will be planning to research on weather forecasts and agro-met advisory over village level in Rukmavati River basin of Kutch, Gujarat region.

- Estimation of carbon dioxide (CO_2) sequestration due to improvements in agriculture in Gujarat.

- Estimation of water availability in different water reservoirs using remote sensing data.