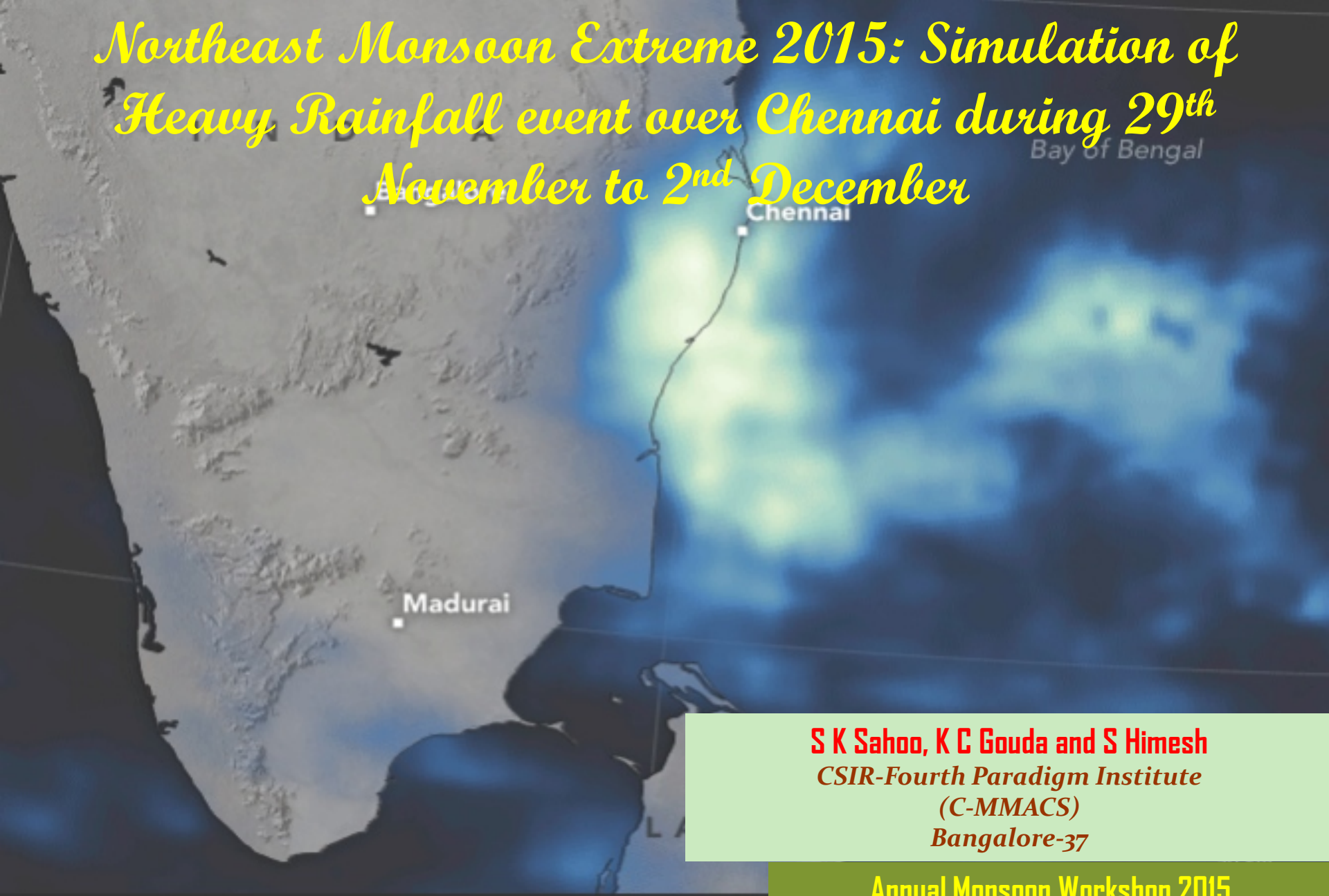
Northeast Monsoon Extreme 2015: Simulation of Heavy Rainfall event over Chennai during 29th November to 2nd December



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Bangalore-37

Annual Monsoon Workshop 2015
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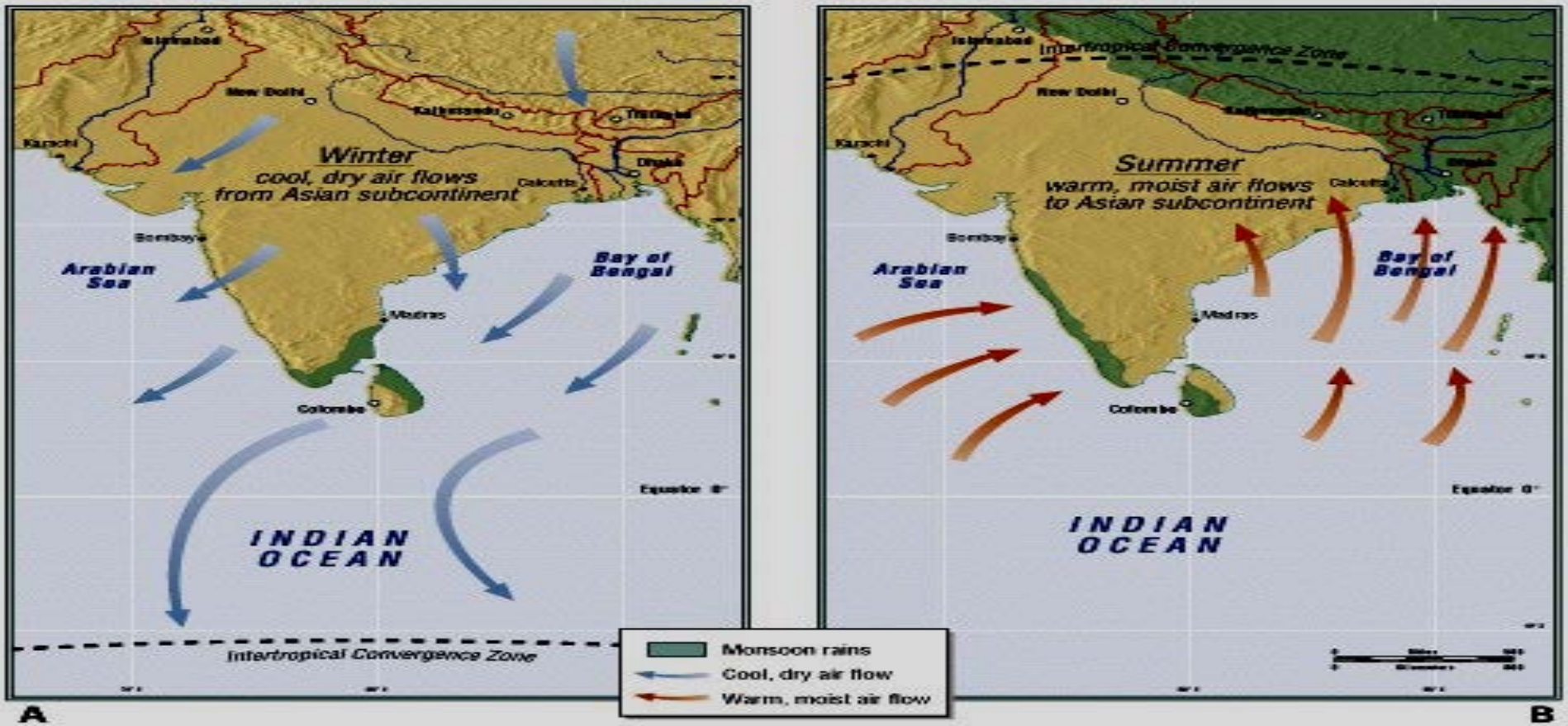
IITM-Pune

Agenda !!

- Introduction
- Objective
- Model Description
- Results
- Conclusions

Introduction:

- Monsoon is a term derived form the Arabic word "*Mausim*", meaning season. It was first used by Arabic navigators to describe the seasonal winds of the Arabian Sea.
- These winds blow from the north-east for one half of the year and from the south-west for the other half.
- India's climate is dominated by monsoons.
- Monsoons are strong, often violent winds that change direction with the season.
- The term technically describes seasonal reversals of wind direction caused by temperature differences between the land and sea breeze, creating zones of high and low pressure over land in different seasons.

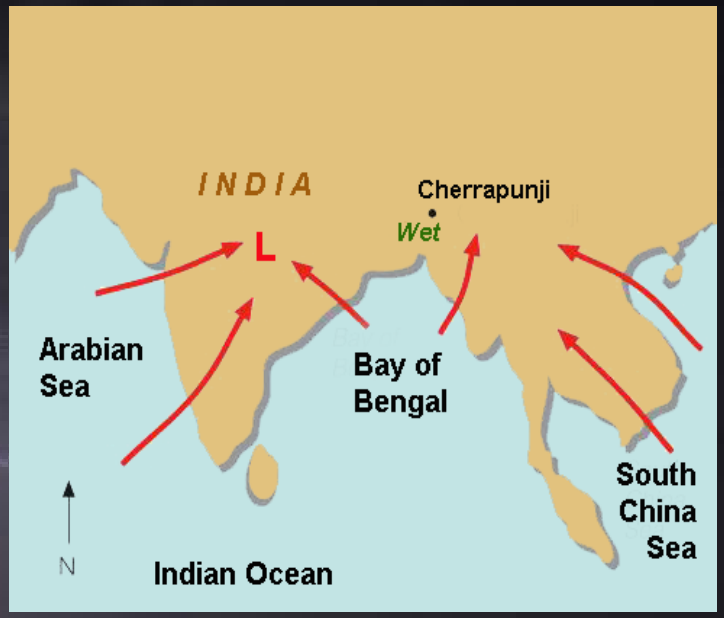


Monsoon in India

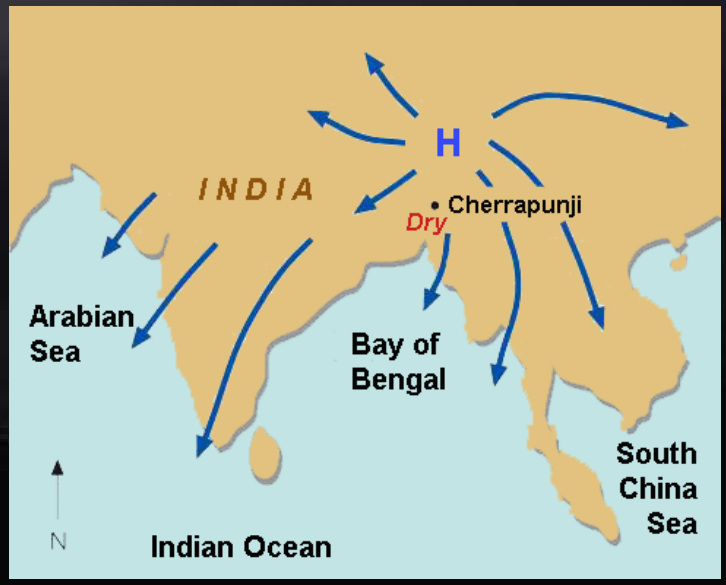
❖ Being a tropical monsoon country there are two monsoon seasons.

❖ *The South–West (summer)* monsoon has warm winds blowing from Indian Ocean. Its span is June to September, with 75 % of the annual rainfall in India. It varies from 10 cm in western Rajasthan to over 900 cm in Meghalaya.

❖ *North-East(winter)* monsoon is characterized by a dry continental air mass blowing from the vast Siberian high pressure area from November to March. The rainfall includes snowfall during winter monsoon which is of the order of 1000 km2 in India. This is also known as Retreating monsoon.



Summer monsoon



Winter monsoon

- **Thus, from October to December the coast of Tamil Nadu state receives at least half of it’s roughly 1,000 mm of annual precipitation**
- **This rainy extension of the generally dry retreating monsoon is called the northeast, or winter monsoon.**
- **Another type of winter precipitation occurs in northern India, which receives weak cyclonic storms originating in the Mediterranean basin.**
- **In the Himalayas these storms bring weeks of drizzling rain and cloudiness and are followed by waves of cold temperatures and snowfall. The state of Jammu and Kashmir in particular receives much of its precipitation from these storms.**
- **At Chennai the pattern of rainfall is different because the monsoon winds blow along the coast. Here, the rainfall increases gradually through the summer months with larger amounts falling in October and November, owing to tropical cyclones traveling westwards across the Bay of Bengal**

EXTREME RAINFALL EVENTS

Climate "extremes" have the greatest impacts on human society & the environment.

i. Heavy rainfall events and Flash Floods
ii. Cold wave, Fog and Snow storms
iii. Hailstorm, Thunderstorm and Dust storms
iv. Heat wave
v. Tropical cyclones and Tidal waves
vi. Droughts

Extreme Rainfall Event:

Intensity of Rainfall

Descriptive Term used	Rainfall amount in mms
No Rain	0.0
Very light Rain	0.1- 2.4
Light Rain	2.5 – 7.5
Moderate Rain	7.6 – 35.5
Rather Heavy	35.6 – 64.4
Heavy Rain	64.5 – 124.4
Very Heavy Rain	124.5 – 244.4
Extremely Heavy Rain	>244.5
Exceptionally Heavy Rain	When the amount is a value near about the highest recorded rainfall at or near the station for the month or season. However, this term will be used only when the actual rainfall amount exceeds 12 cm.

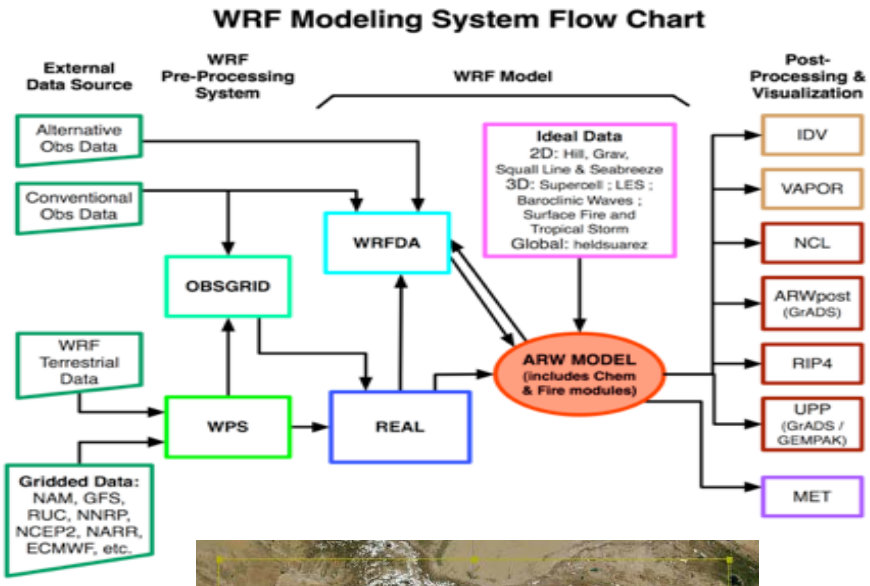
Source: http://www.imd.gov.in/section/nhac/dynamic/termglossary.pdf

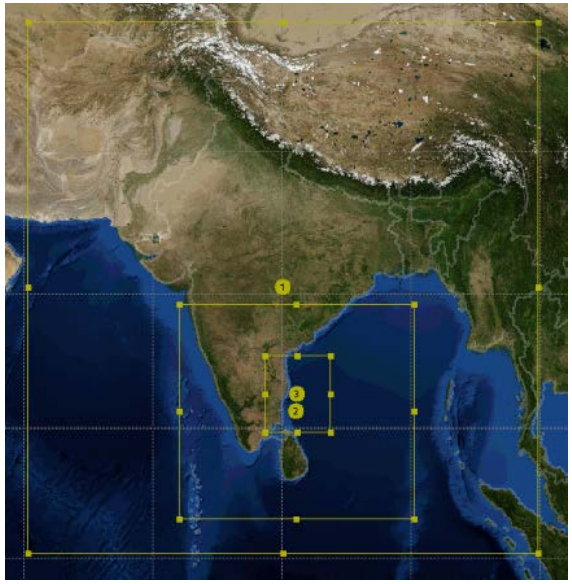
Objective:

- Model configuration for the simulation of heavy rainfall events (over coastal city like Chennai.)
- To asses the ability of WRF meso-scale Model to simulate the rare Event & its Intensity, Location & Large scale systems.
- Identification of processes and mechanisms of urbanization which affect heavy rainfall events

The Modelling Approach for ERE Simulation

Overview of Weather Research & Forecasting (WRF) Model





Model Configuration:

Dynamics	Non-hydrostatic
Number of domains	Three nested domains
Horizontal resolutions	18 km (outermost domain), 6 km (inner domain) and 2 km (innermost domain).
Number of grid points	X-direction 224, 310 and 259, Y-direction 234, 283 and 301 points for Outermost, inner and innermost domains respectively.
Map projection	Mercator
Horizontal grid	Arakawa C-grid
Vertical Level	19
Time integration	Third-order Runge–Kutta
Spatial difference scheme	Sixth-order centered difference
Microphysics	WSM6 scheme
Radiation	RRTM: Longwave Dudhia: Shortwave
Cumulus parameterization	Grell-Freitas ensemble scheme
PBL parameterization	YSU scheme
Land surface parameterization	Noah Land-surface Model

Continued…..

Weather Research & Forecasting (WRFV3.5 Model)

- **Model Configuration:** The model will be optimally configured with the careful selection of domain size and geographical coverage, horizontal and vertical resolution, physics options, and parameterization schemes.

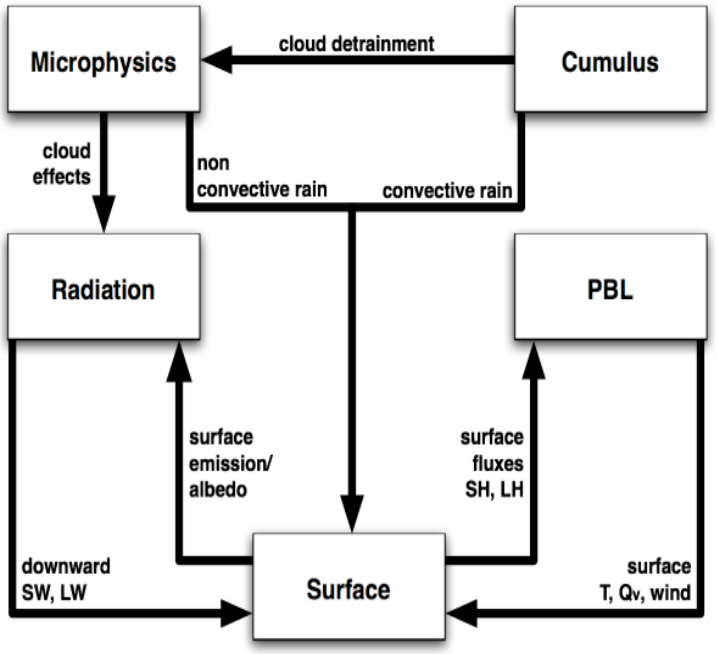
- **Initial and Boundary Data:** The FNL (Final) global analysis data. This data set is a 6- hourly product on a 1^{o} x1^{o} grid from the Global Forecast System (GFS) which runs operationally at the National Centre for Environment Protection (NCEP).

Model Physics:

WRF Physics

- Radiation
  - Longwave (ra_lw_physics)
  - Shortwave (ra_sw_physics)
- Surface
  - Surface layer (sf_sfclay_physics)
  - Land/water surface (sf_surface_physics)
- PBL (bl_pbl_physics)
- Turbulence/Diffusion (diff_opt, km_opt)
- Cumulus parameterization (cu_physics)
- Microphysics (mp_physics)

Direct Interactions of Parameterizations

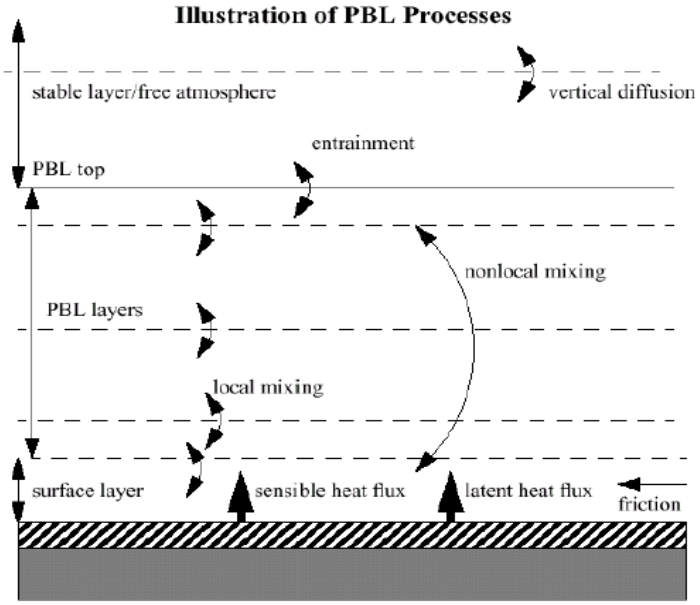


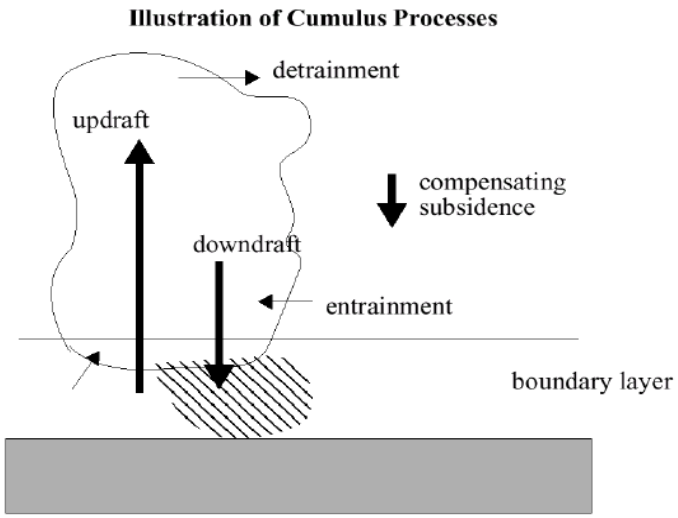
Model Physics

1. **Mp-Physics (WSM6):** Microphysics includes explicitly resolved water vapor, cloud, and precipitation processes. A scheme with ice, snow and graupel processes suitable for high-resolution simulations.
2. **Cu-Physics (Grell-Freitas)**: Adjustment and mass-flux schemes for mesoscale modeling. An improved GD scheme that tries to smooth the transition to cloud-resolving scales, as proposed by Arakawa et al. (2004)
3. **SF_Surface_physics** (Noah Land Surface Model): Multi-layer land surface models ranging from a simple thermal model to full vegetation and soil moisture models, including snow cover and sea ice. Unified NCEP/NCAR/AFWA scheme with soil temperature and moisture in four layers, fractional snow cover and frozen soil physics. New modifications are added in Version 3.1 to better represent processes over ice sheets and snow covered area
4. **Bl_pbl_physics(YSU)**: Turbulent kinetic energy prediction or non-local K schemes.
5. **Atmospheric radiation physics**: Longwave and shortwave schemes with multiple spectral bands and a simple shortwave scheme suitable for climate and weather applications. Cloud effects and surface fluxes are included.

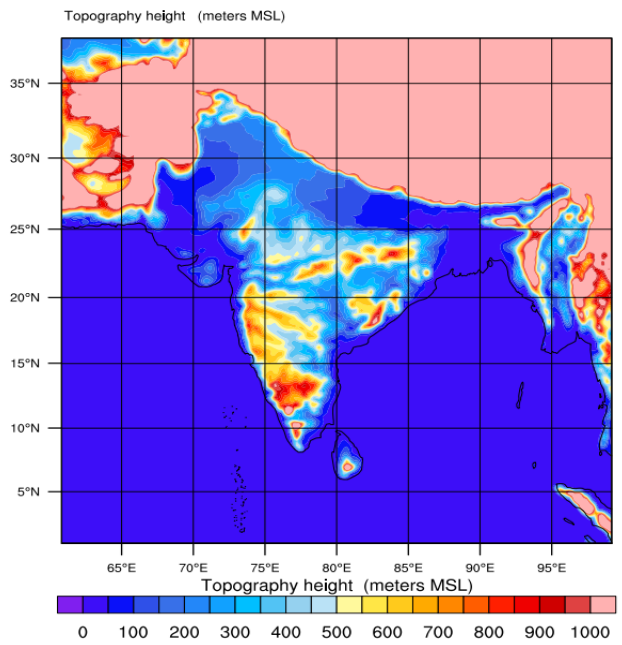
   (a)RRTM Long wave : Rapid Radiative Transfer Model. An accurate scheme using look-up tables for efficiency. Accounts for multiple bands, and microphysics species. For trace gases, the volume-mixing ratio values for CO2=330e-6, N2O=0. and CH4=0.

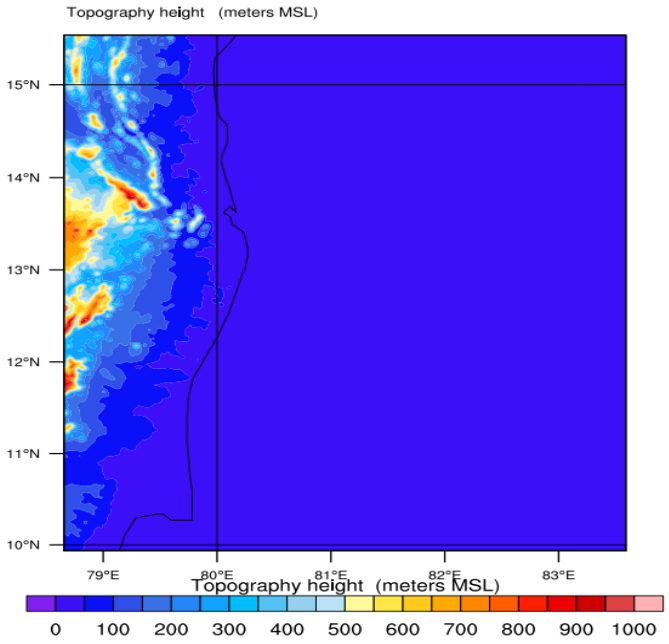
   (b)Dudhia Short wave : Simple downward integration allowing efficiently for clouds and clear-sky absorption and scattering



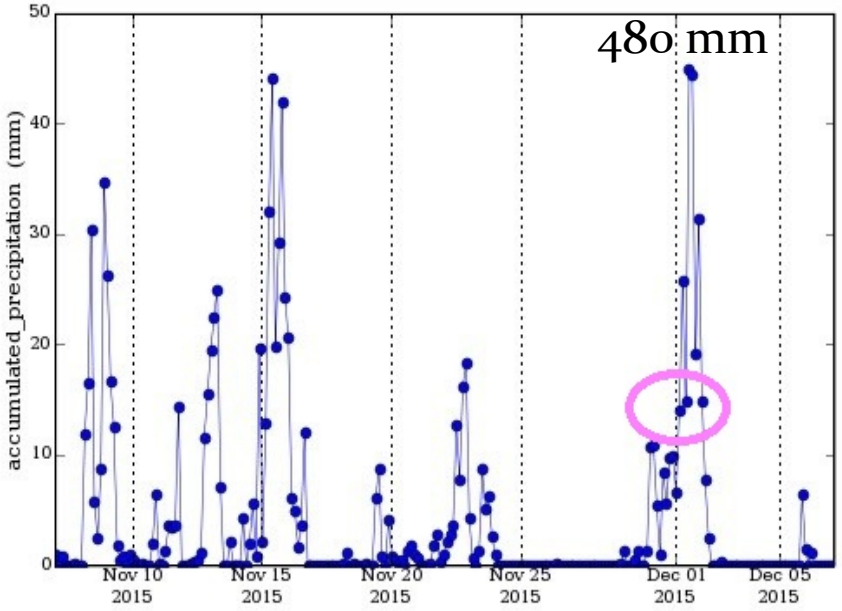


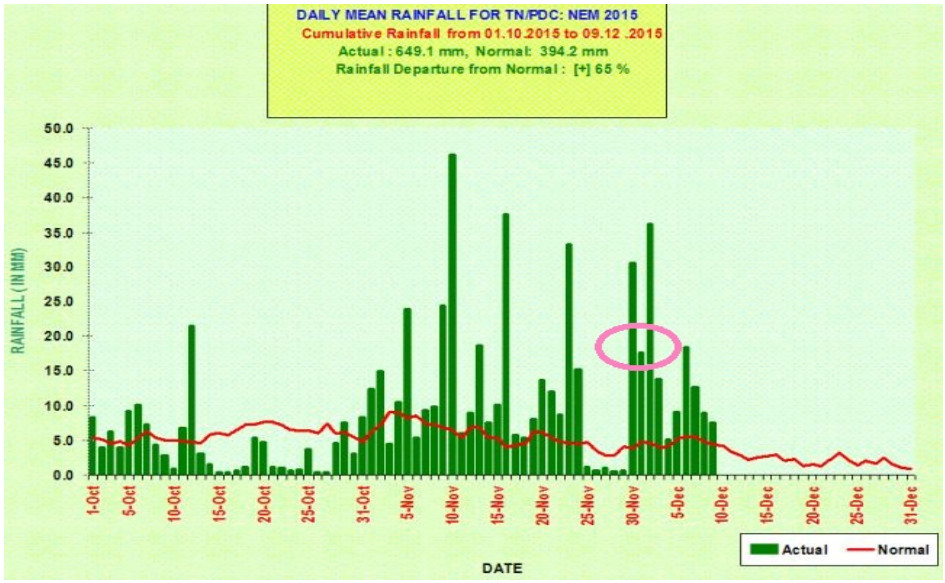
Terrain Height used for Outer and Inner Domain





Observed Rainfall over Chennai (Nov 7-Dec 7, 2015) TRMM & IMD



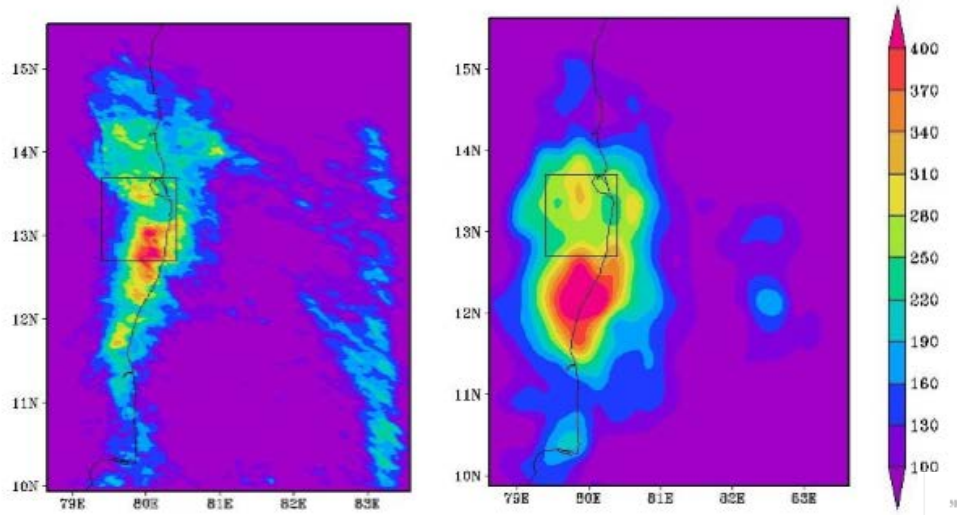


Pink Circle represents the Peak in Rainfall observed

So in Simulation the model integration will be during 29th Nov to 2nd Dec 2015

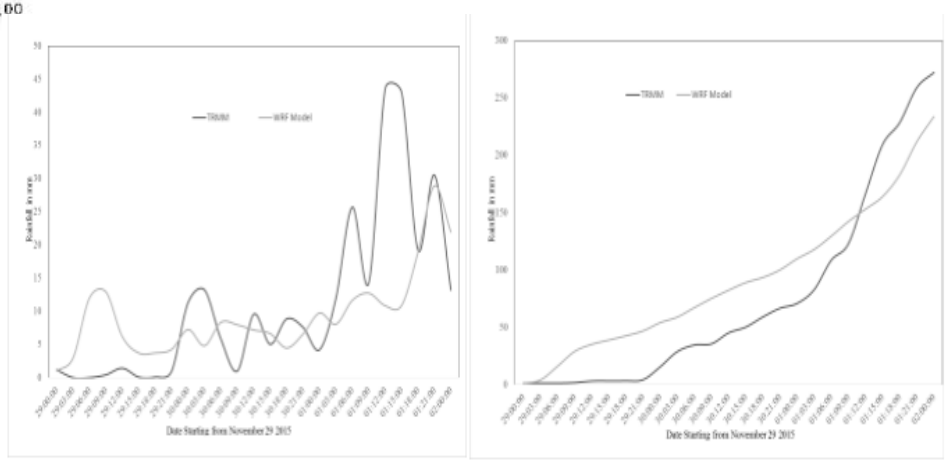
Results:

Comparison between Model Simulated & TRMM observed Rainfall



Spatial map of Chennai Heavy Rainfall event from Nov 29-Dec 2, 2015. Box (79.4E-80.4E,12.7N-13.7N) is centered over Chennai.

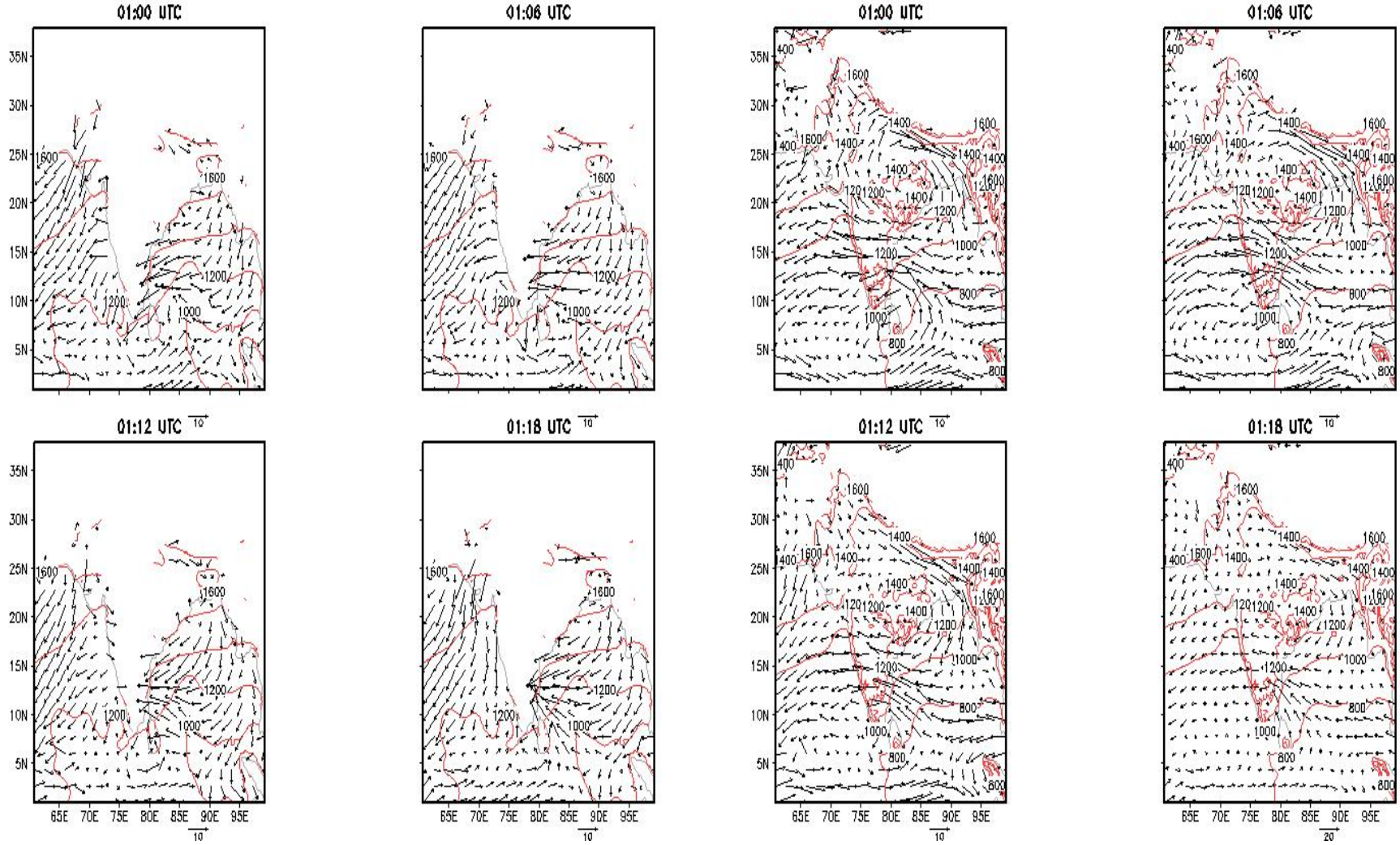
IMD Rainfall (mm)	TRMM (mm)	Model(Ensemble simulation) (mm)	% of Error wrt IMD	% of Error wrt TRMM
490	471	431	12	8.5



Time series of total accumulated rainfall(box avg) from Nov 29-Dec 2, 2015.

Wind Vector at Surface and 850 levels with Pressure on 01st Dec 2015

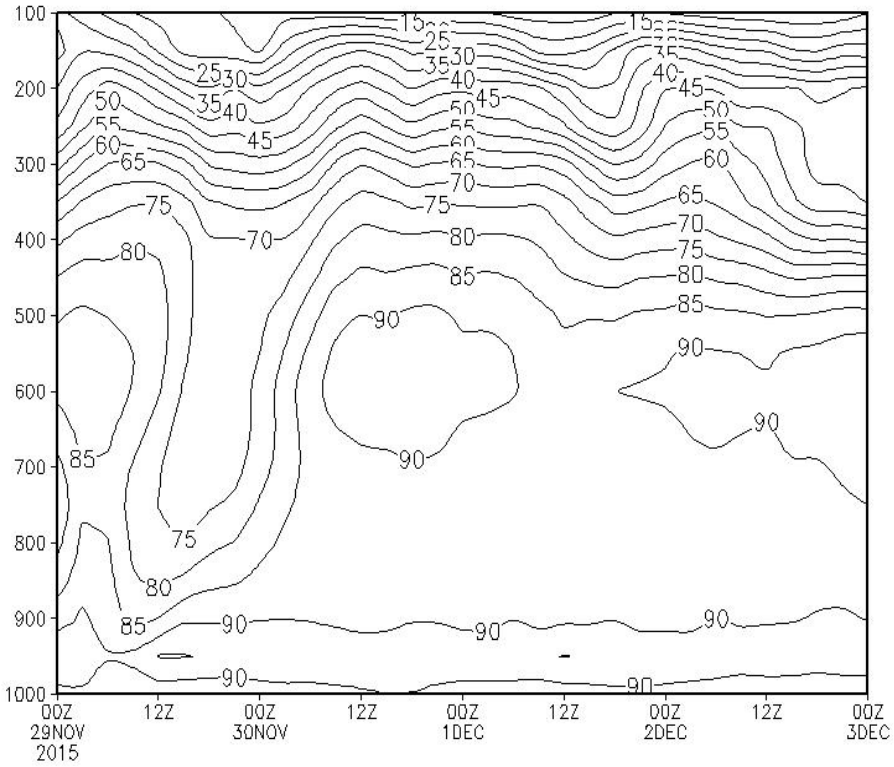
(A)

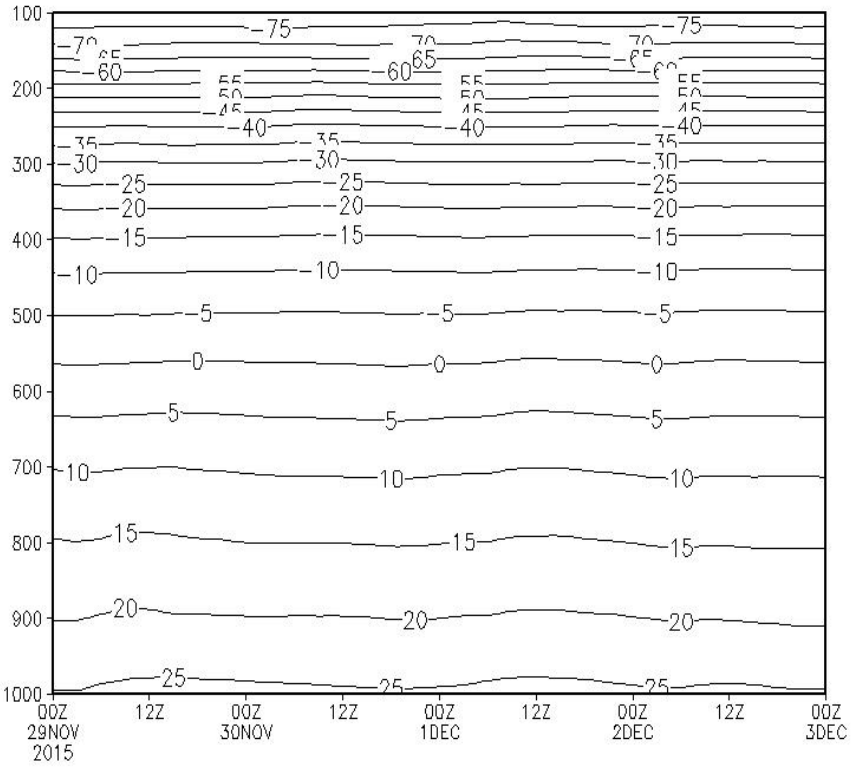


Surface Level

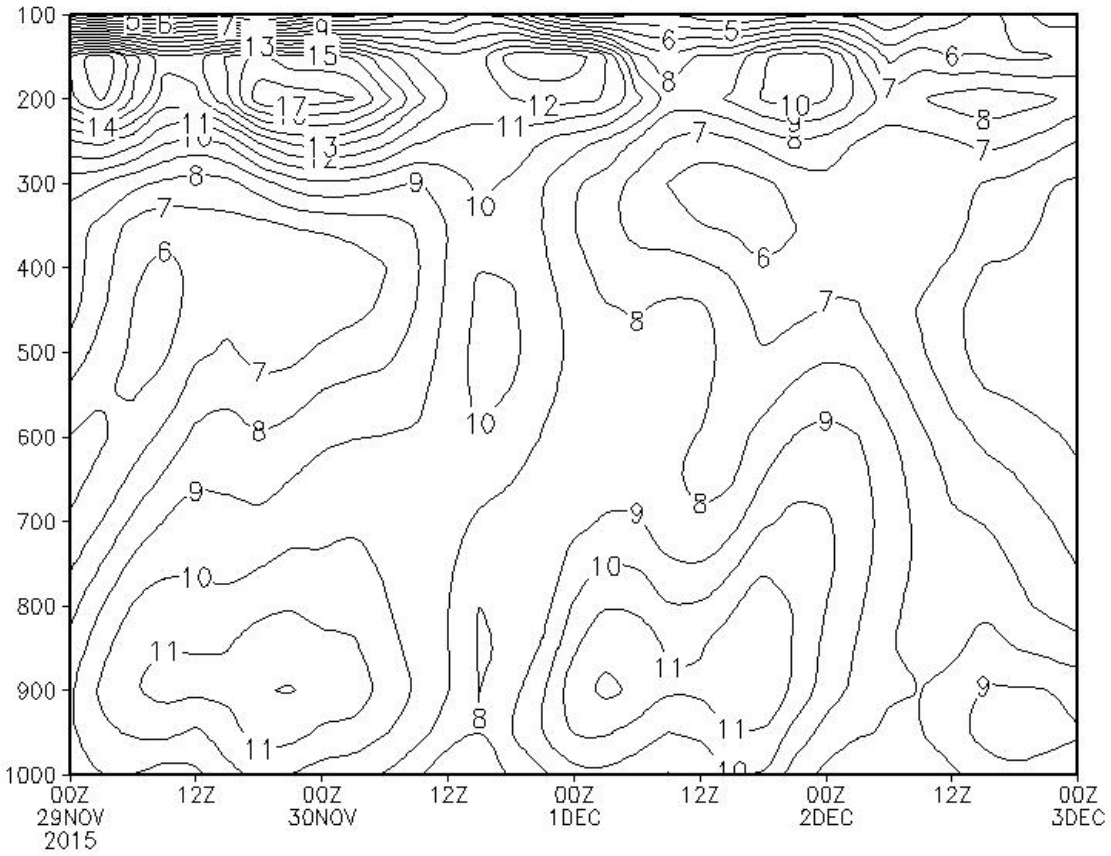
850 Level

Time height Structure of Relative Humidity & Temperature:





Time height Structure of Model derived Vertical Wind:



Conclusion & Future Work:

- The HPC enabled meso-scale model (WRF) platform is well configured to predict the ERE over Coastal India
- Along with Rainfall, other synoptic features are also well simulated by the model.

- Comparative analysis of the entire cycle of NE-monsoon over Chennai using GCM and WRFV3.
- Detailed investigation into historical extreme events during NE-monsoon over Chennai.

Acknowledgments

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Thanks a lot.....