Scientific Advisory Committee (SAC) Review: 2009

D. Bala Subrahamanyam
SPL, VSSC

Organization of Presentation

- Location Specific Weather Prediction using HRM[1]
- Nowcasting at Sriharikota through ARPS[2] Model during Chandrayaan-1 launch campaign
- Characterization of Marine Atmospheric Boundary Layer over Bay of Bengal during ICARB-W[3]
- MOKSHA[4] - Pilot Phase Campaign: An Overview
- Regional Climate Modelling: A New Initiative

[1]High-resolution Regional Model
[2]Advanced Regional Prediction System
[3]Integrated Campaign for Aerosols, gases and Radiation Budget - Winter
[4]Monsoon Onset over Kerala through Systematic Horizontal Advection

Location specific weather prediction over Sriharikota through High-resolution Regional Model (HRM)

[PSLV-C11 (Chandrayaan-1) and PSLV-C12 launch campaigns]

Contributors:

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[1]SPL, VSSC, Thiruvananthapuram

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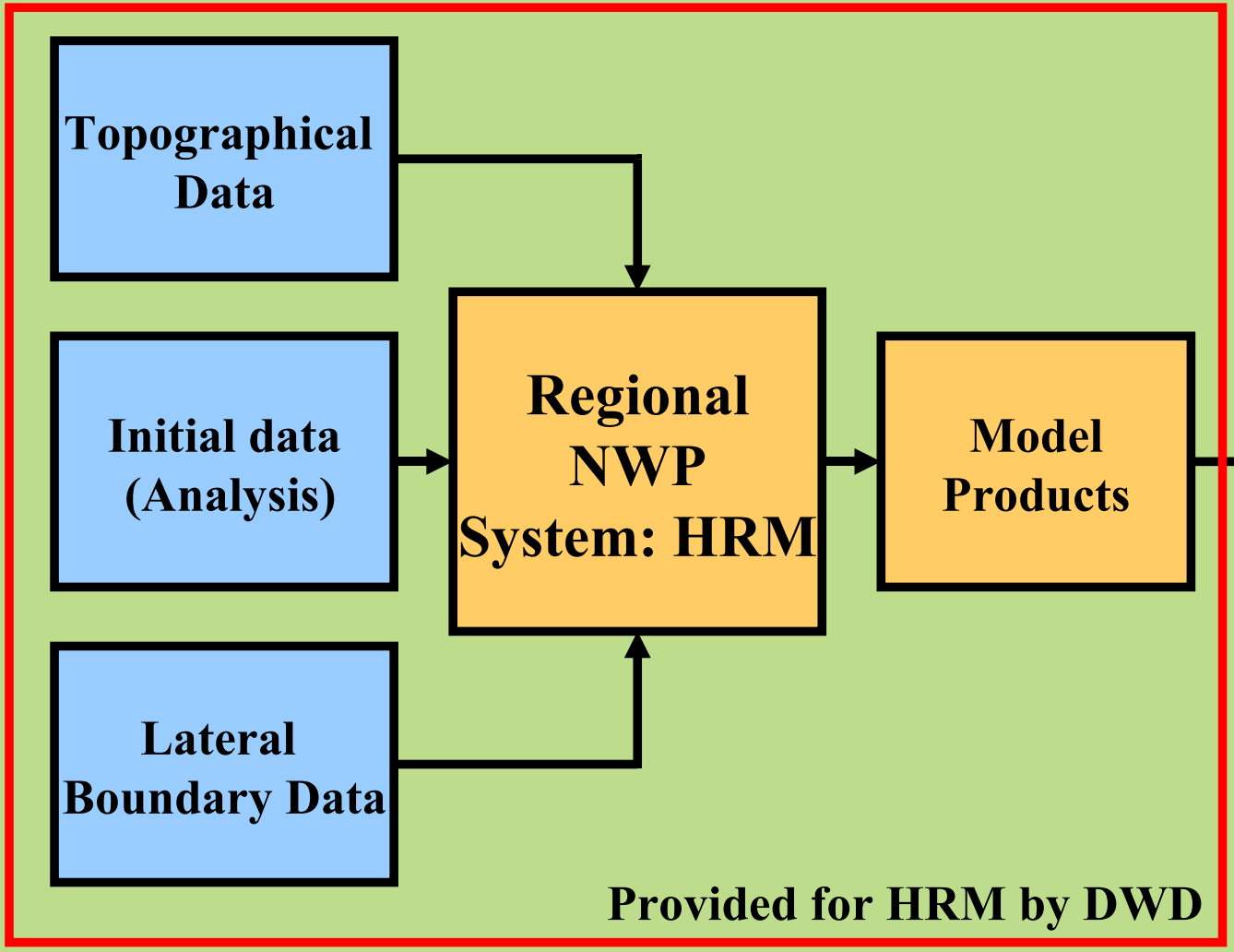
Modelling Strategy for "Location Spectific (SHAR) Weather Prediction during Launch Campaigns" (What makes SPL's approach Novel and Unique !)

Numerical Weather Prediction through Regional Atmospheric Models (HRM)

+

Mesoscale Atmospheric Model (ARPS): Customized for highly localized region

General Structure of Regional NWP System: High-resolution Regional Model (HRM): An Overview



Some Salient Features of HRM:

Hydrostatic Model
Forced by DWD Global Model (GME)
Indian Domain (0 – 30 N; 65E – 95E)
Horizontal Resolution: ~10 km to 28 kms
Domain Centered around SHAR

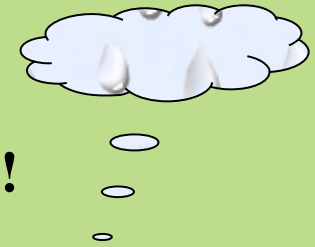
Operational at SPL since 2002:

Location specific (SHAR) forecast
Systematic Seasonal Bias Studies
Sea/Land Breeze over Thumba
Mountain Wave Simulations
...

HRM Simulations during PSLV-C11 (Chandrayaan-1) and PSLV-C12 Launch Campaigns

What was so special during these two campaigns ?

(1) **PSLV-C11 (Chandrayaan-1): October 22, 2008**
Campaign Period (October 13 – 22, 2008)

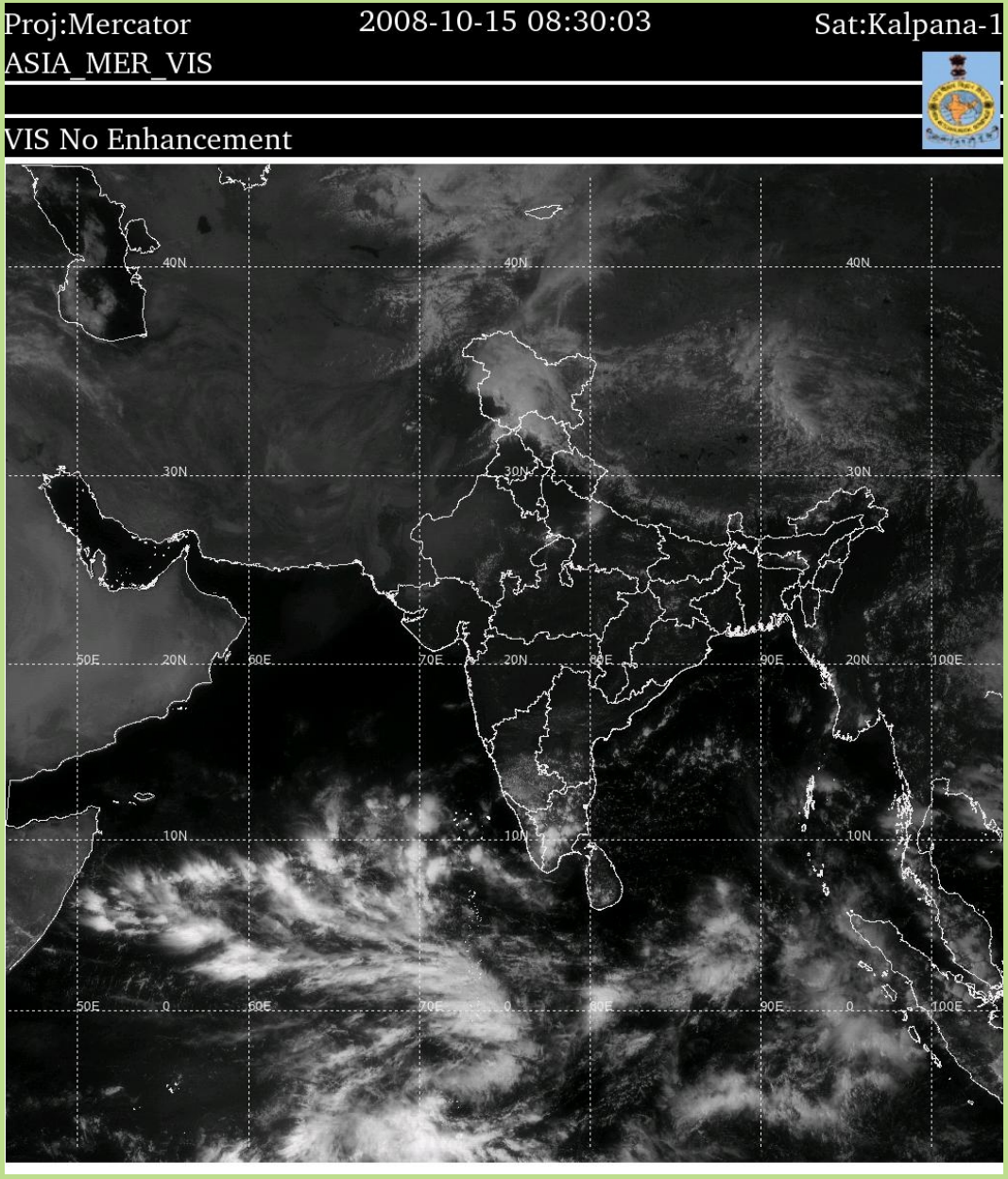


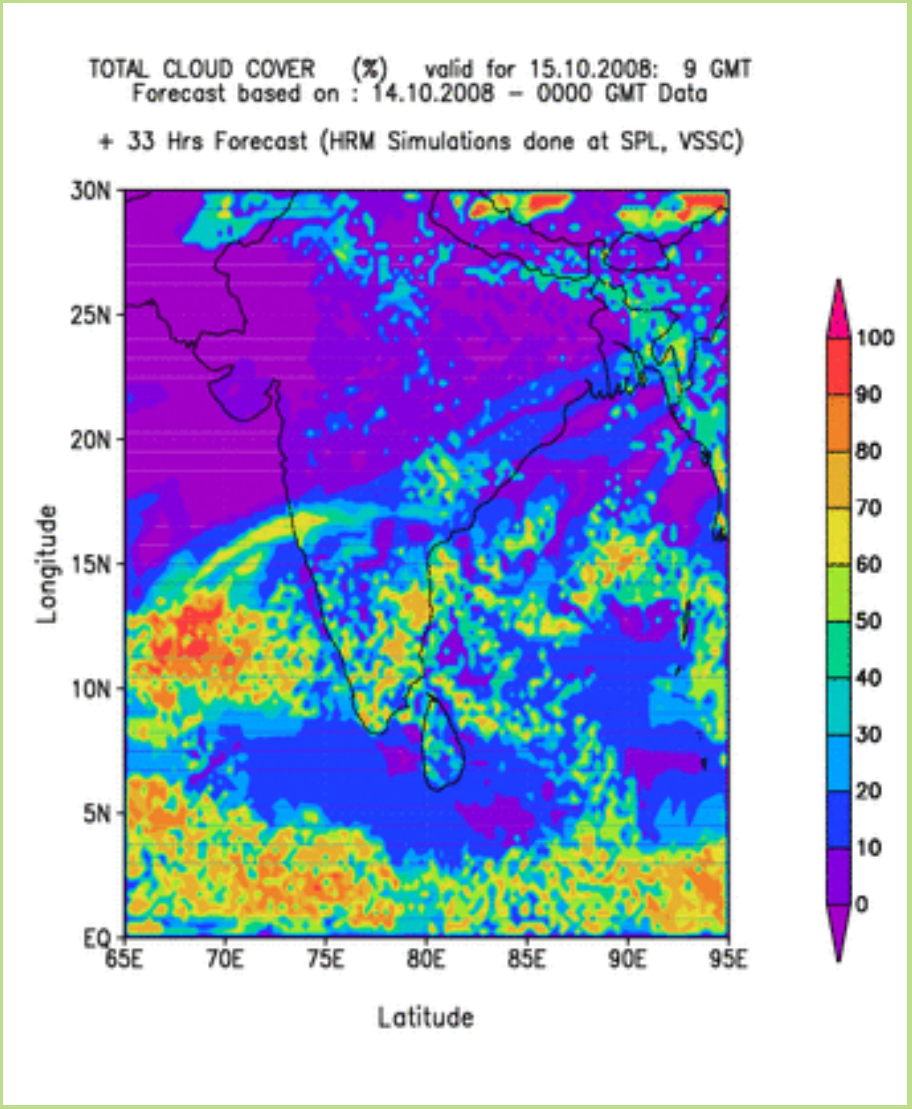
Coincided with the normal onset dates of NE monsoon, generally associated with frequent showers and thunderstorms over SHAR !

(2) **PSLV-C12 (RISAT, ANUSAT...): April 20, 2009**
Campaign Period (April 13, 2009)

Northern Indian Ocean experienced one of the disturbed weather events during April 14 – 17, 2009 which was designated as 'BIJLI' cyclonic storm by IMD (intensity ~ 75 km/hr). Its movement was west-northwestward !

Comparison of HRM simulated total cloud cover with the Observations during PSLV-C11 (Chandrayaan-1) Launch Campaign



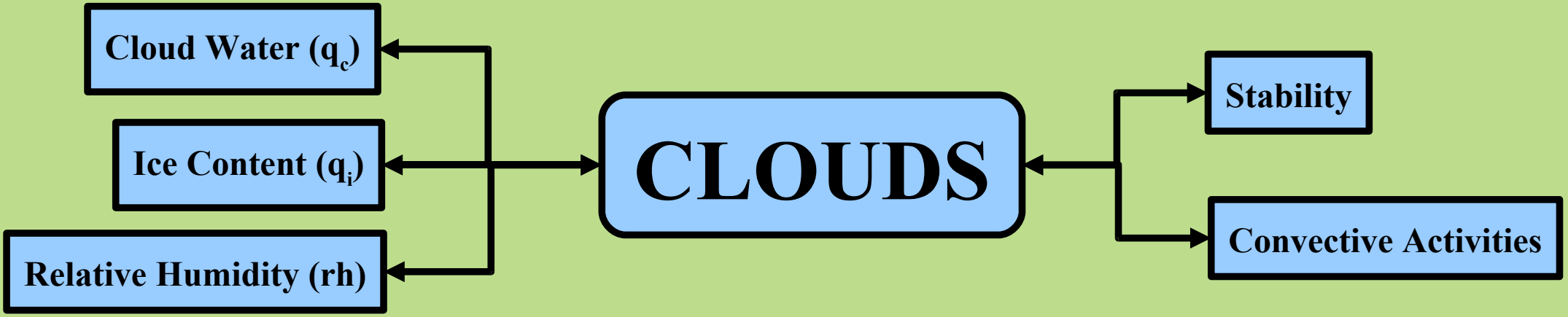


+33 Hours Predictions: Good or Bad ?

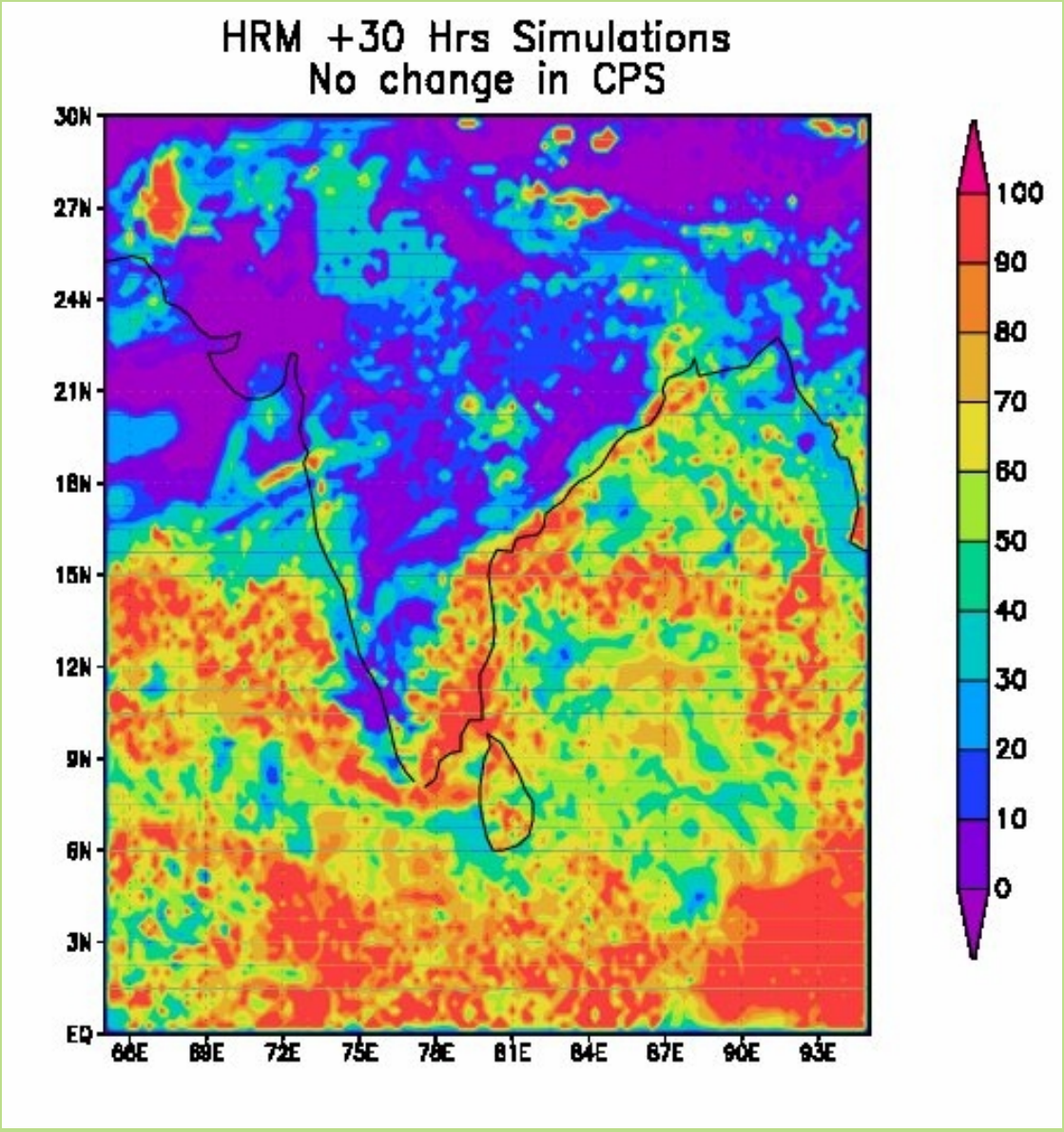
How do we go ahead for improving the Cloud Parameterization Scheme[#] ?
For a given region (in modeler's point of view: GRID)...:
FOR A LAYMAN'S LANGUAGE --->

MODEL	OBSERVATIONS	CONCLUSION
NO CLOUDS	NO CLOUDS	VERY GOOD
NO CLOUDS	PARTIAL CLOUDY	NEED IMPROVEMENTS
NO CLOUDS	DENSE CLOUDS	UNDER-ESTIMATION
.....		
DENSE CLOUDS	NO CLOUDS	OVER-ESTIMATION
DENSE CLOUDS	PARTIAL CLOUDS	NEED TUNING
DENSE CLOUDS	DENSE CLOUDS	VERY GOOD

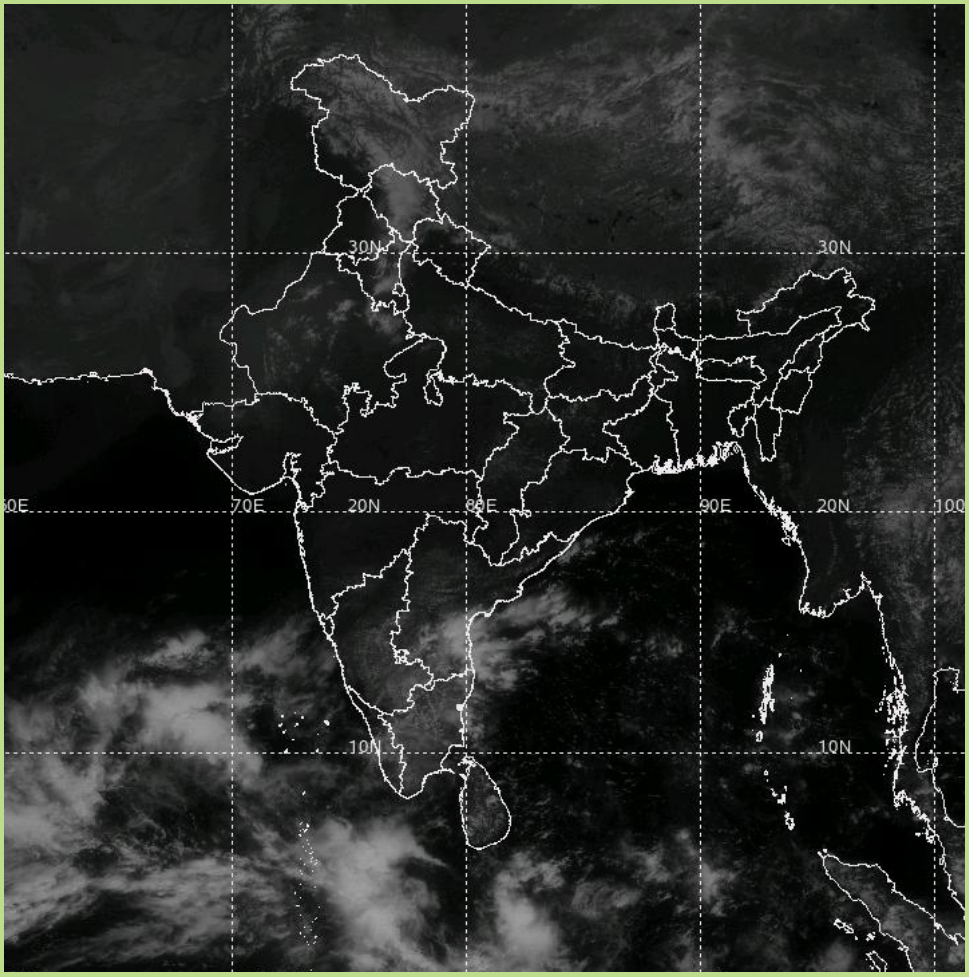
[#]Ritter and Geleyn, 1992: Cloud Parameterization Scheme in HRM



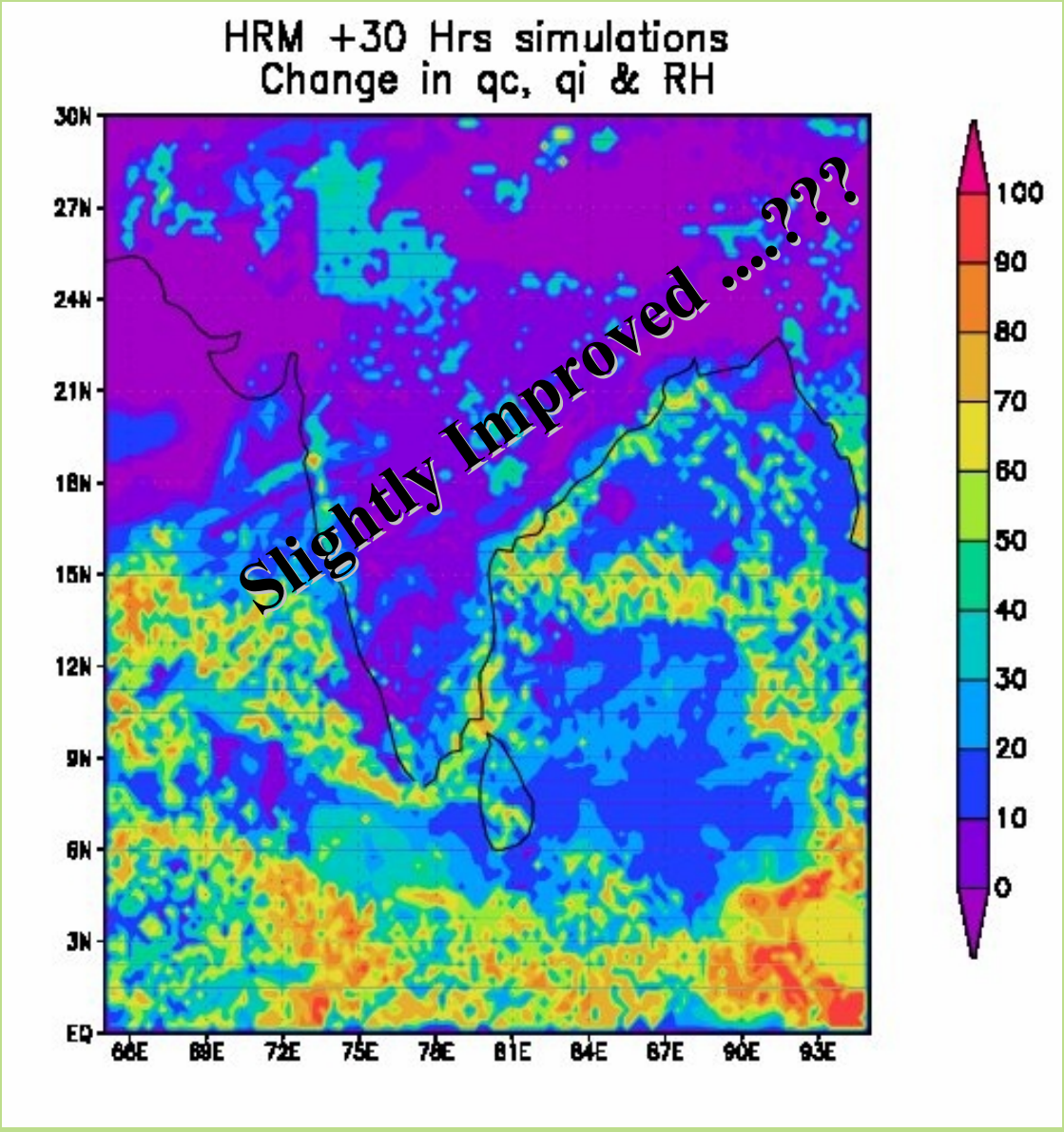
Alterations in Cloud Parameterization Scheme (Subroutine)# .... +30 Hrs HRM Simulations for 16th October 2008 (1200 LT)



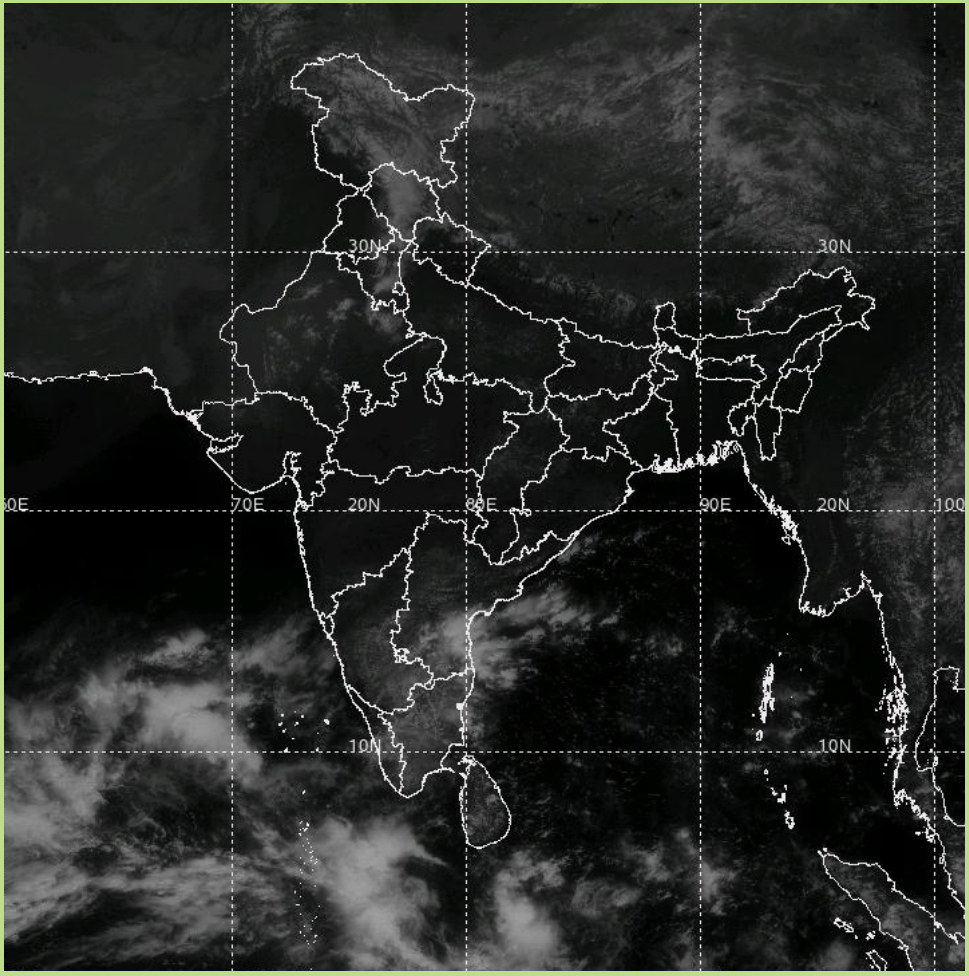
KALPANA Satellite (Visible Range) Clouds
Courtesy: IMD Website



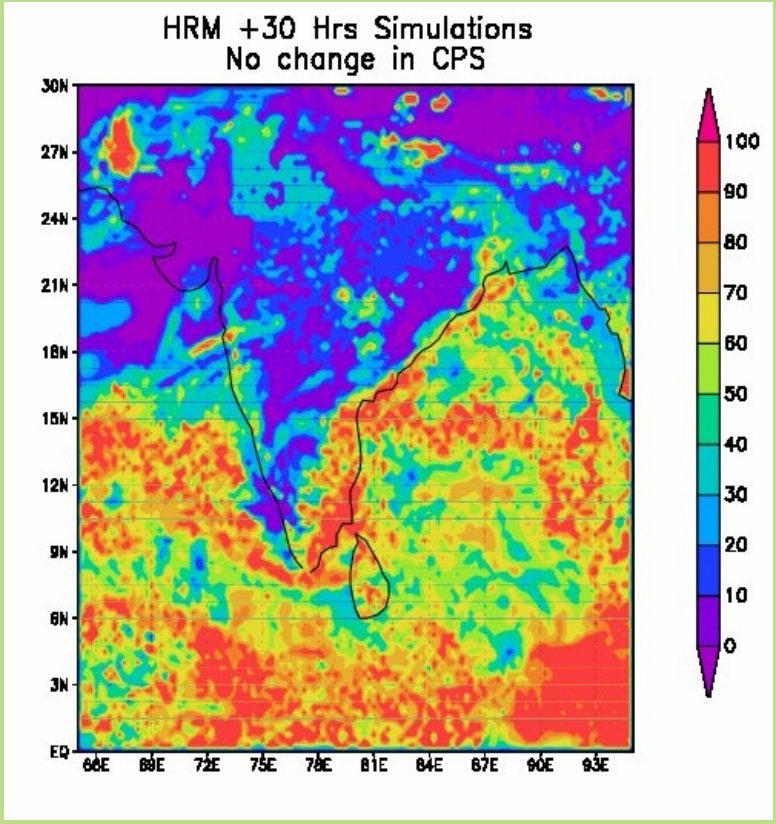
Alterations in Cloud Parameterization Scheme (CPS Subroutine).. +30 Hrs HRM Simulations for 16th October 2008 (1200 LT)

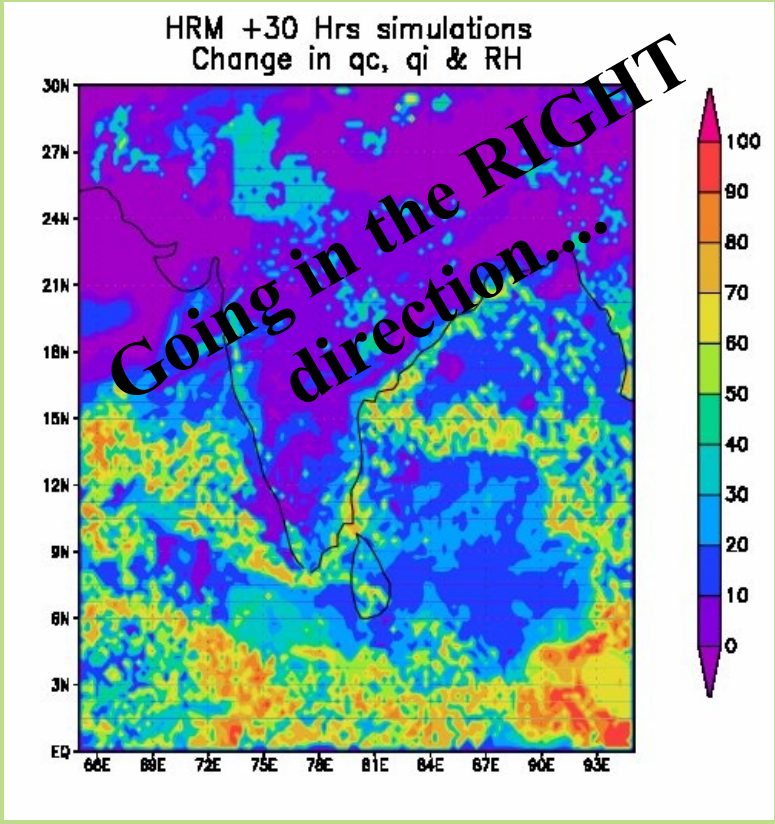


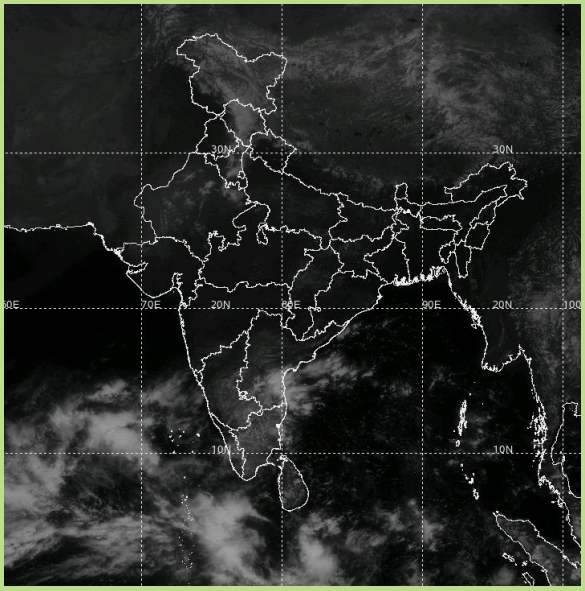
KALPANA Satellite (Visible Range) Clouds
Courtesy: IMD Website



Alterations in Cloud Parameterization Scheme (Subroutine)# .... +30 Hrs HRM Simulations for 16th October 2008 (1200 LT)

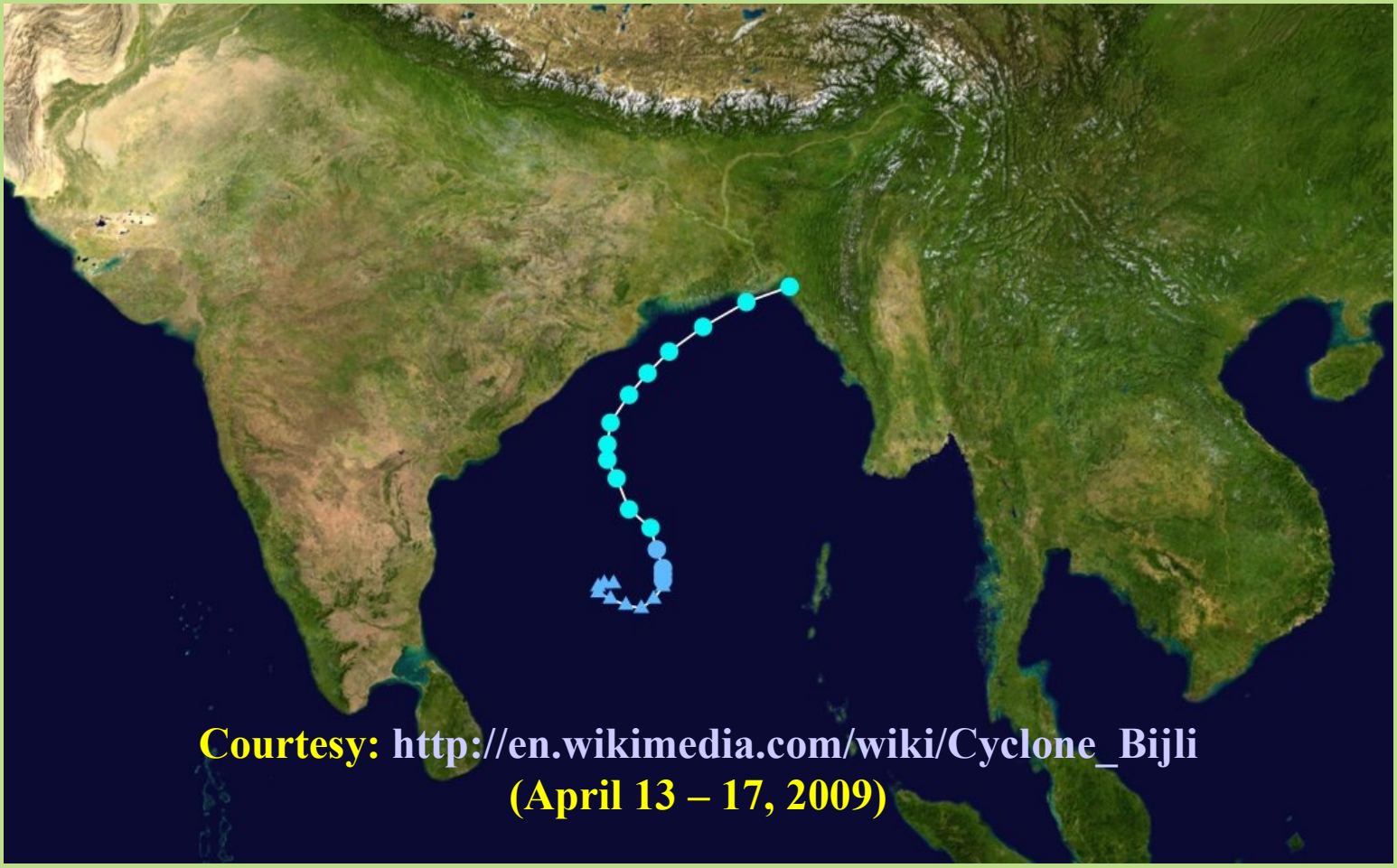






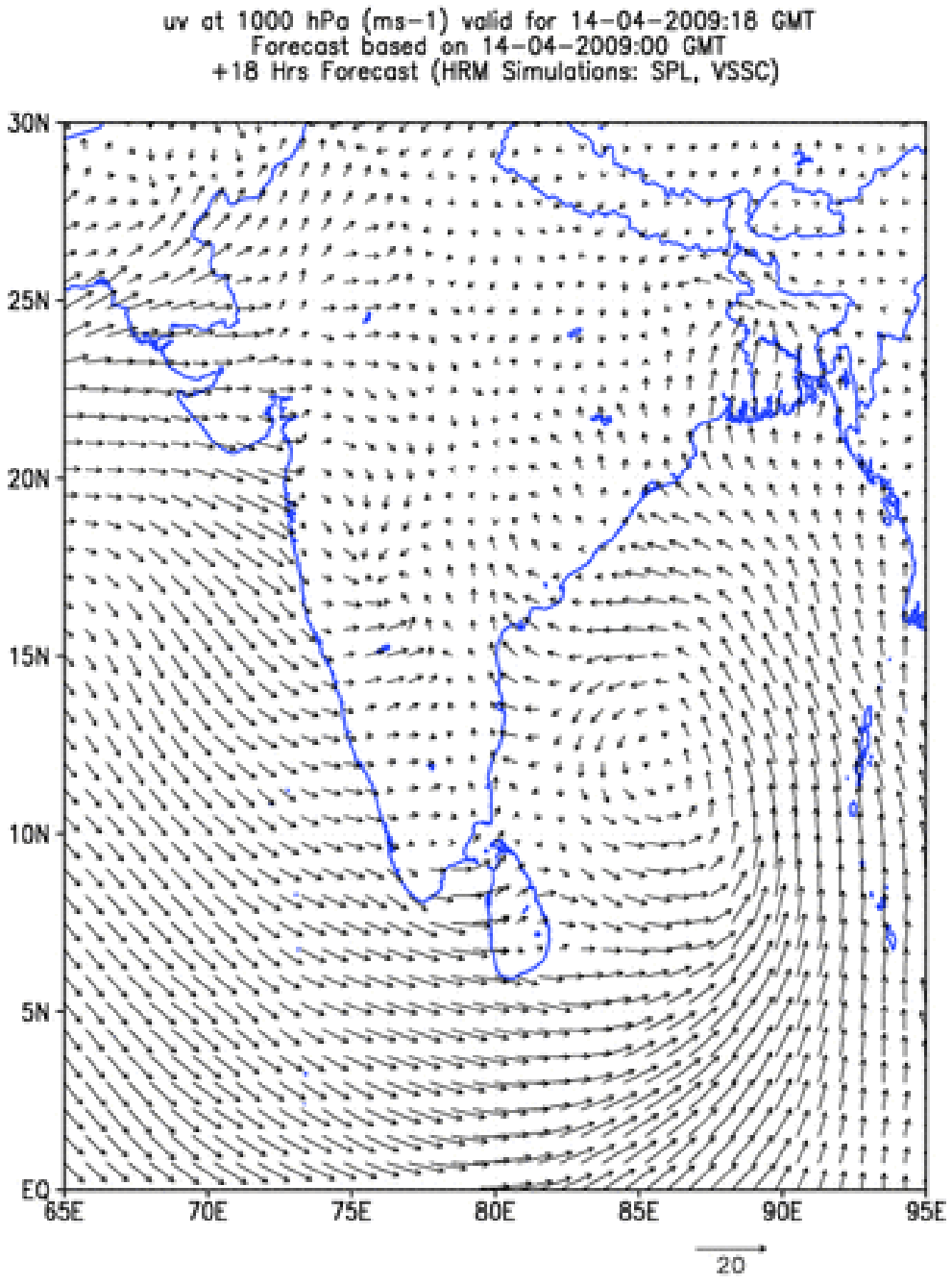
At this juncture, we are not in a position to conclude that – modified cloud parameterization scheme is doing better (or worser), but this research exercise has given us a good boost to get deeply involved in the model code and to tune them for our domain ....

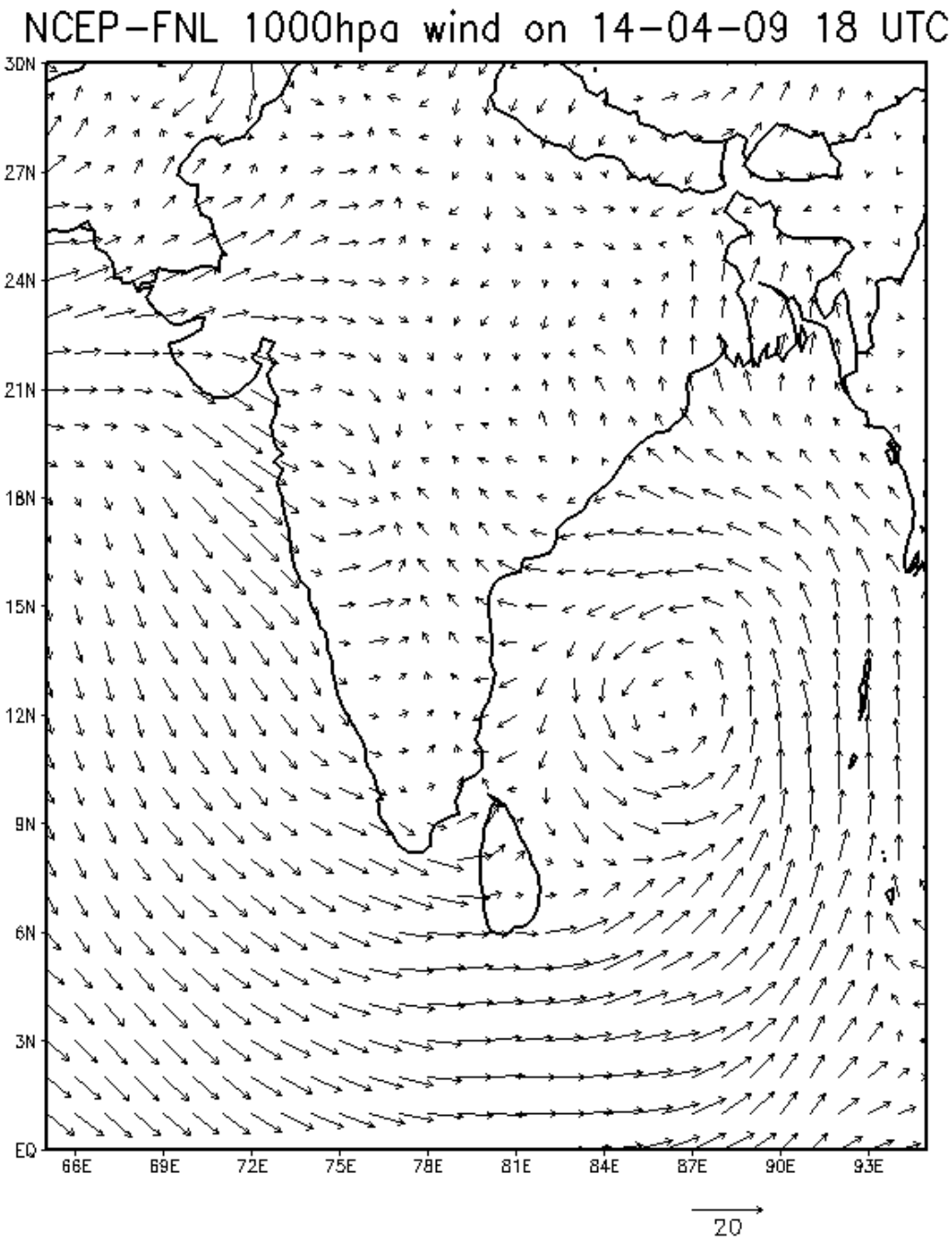
HRM Simulations during PSLV-C12 Launch (April 20, 2009) Campaign
(Criticalities involved due to formation of BIJLI Cyclonic Storm Event)



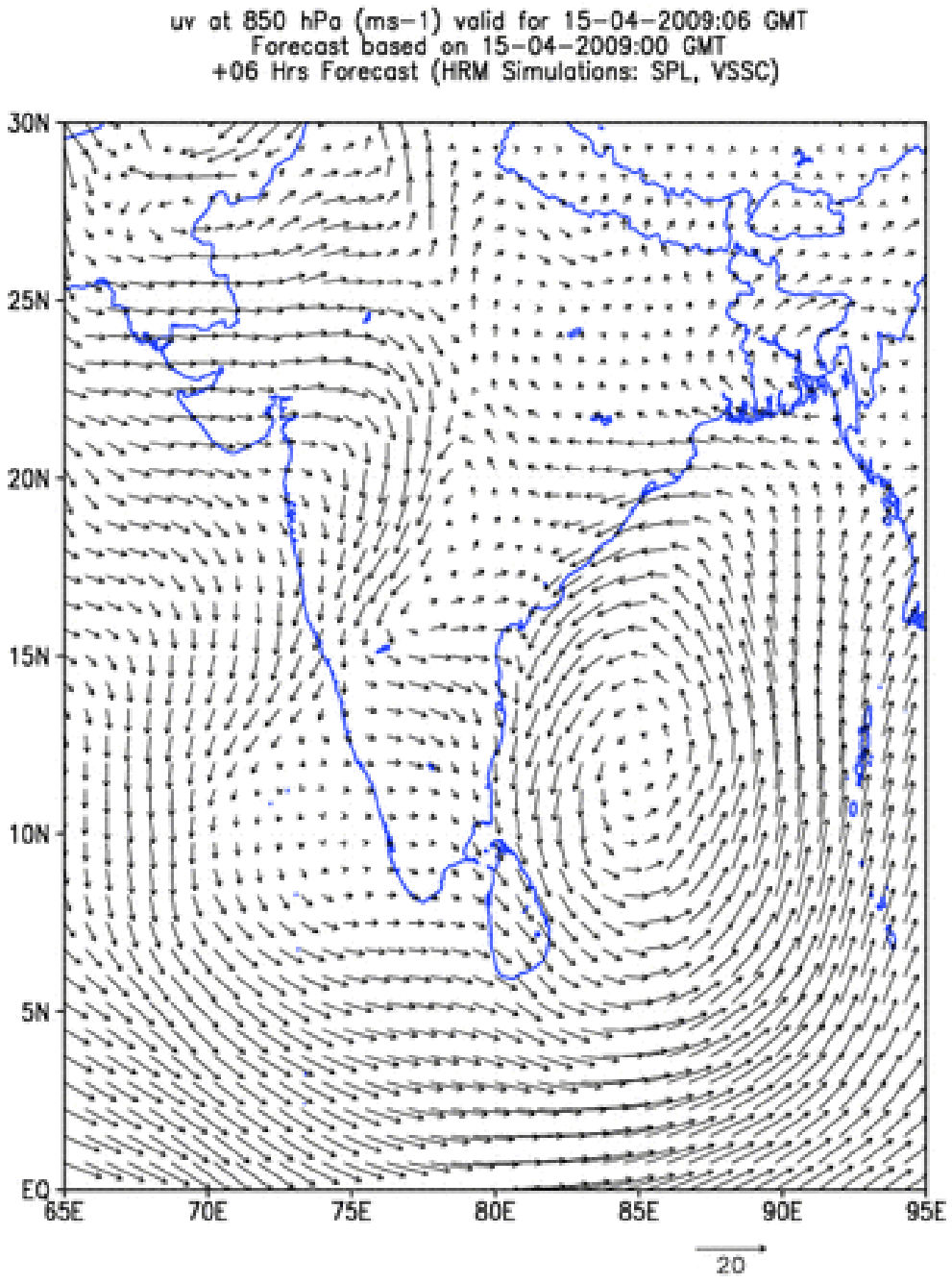
Crucial Forecasting Products during this event were:
(1) 700 hPa RH (2) 850 & 1000 hPa Wind Vectors
(3) Wind Shear over SHAR (4) Stability Parameters (CAPE and CINE)

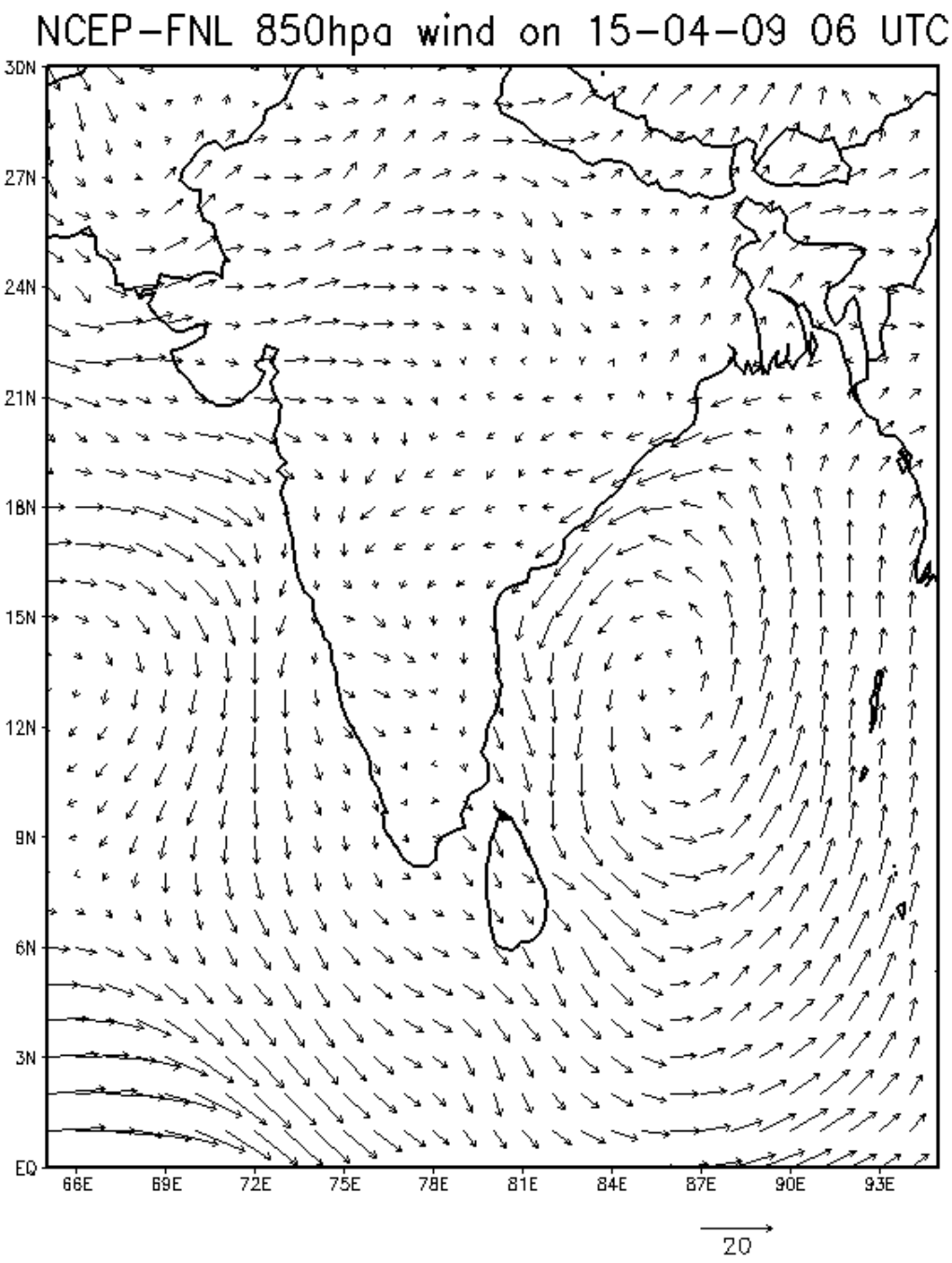
HRM Simulated UV-Wind Vector vs. NCEP-FNL Reanalysis at 1000 hPa



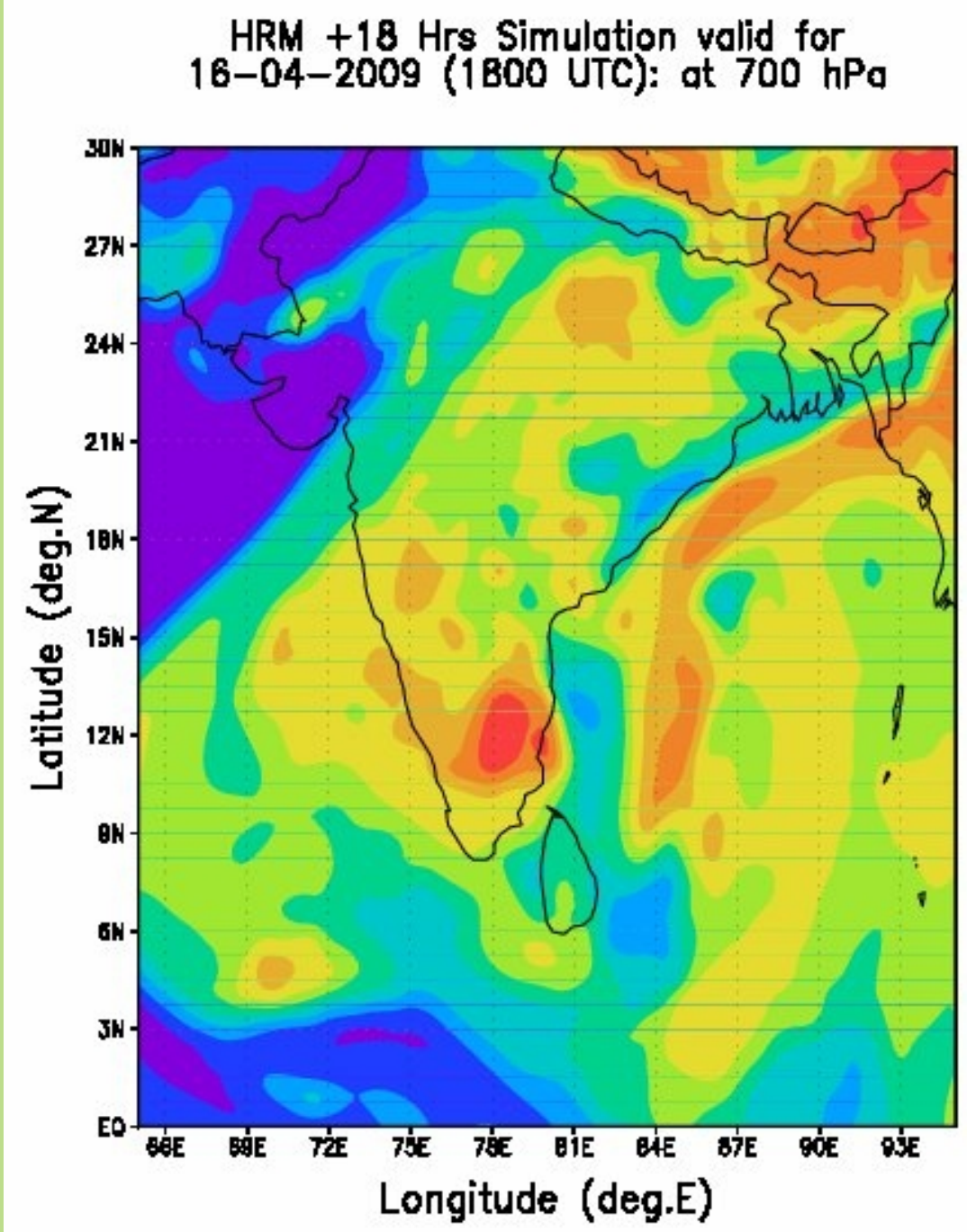


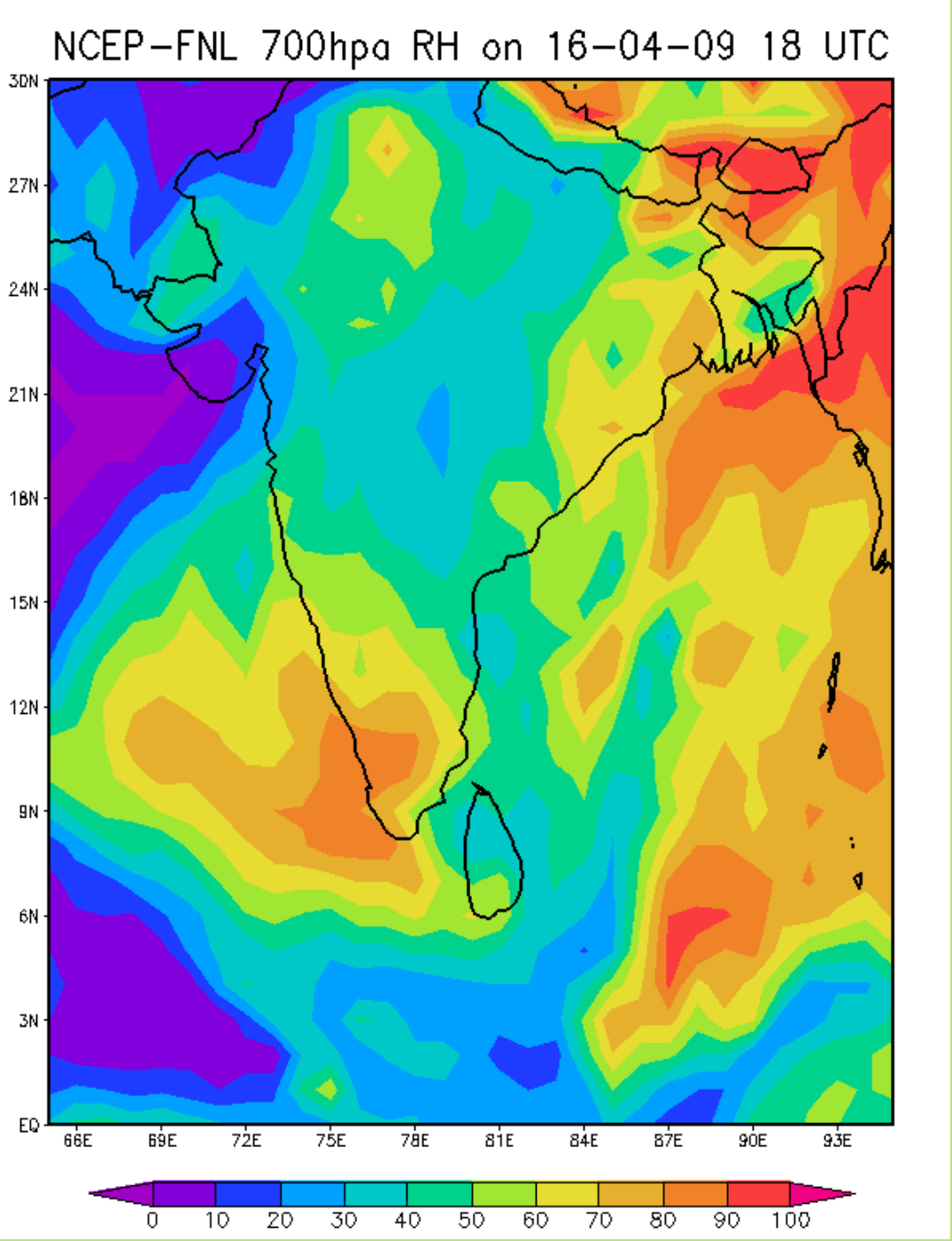
HRM Simulated UV-Wind Vector vs. NCEP-FNL Reanalysis at 850 hPa



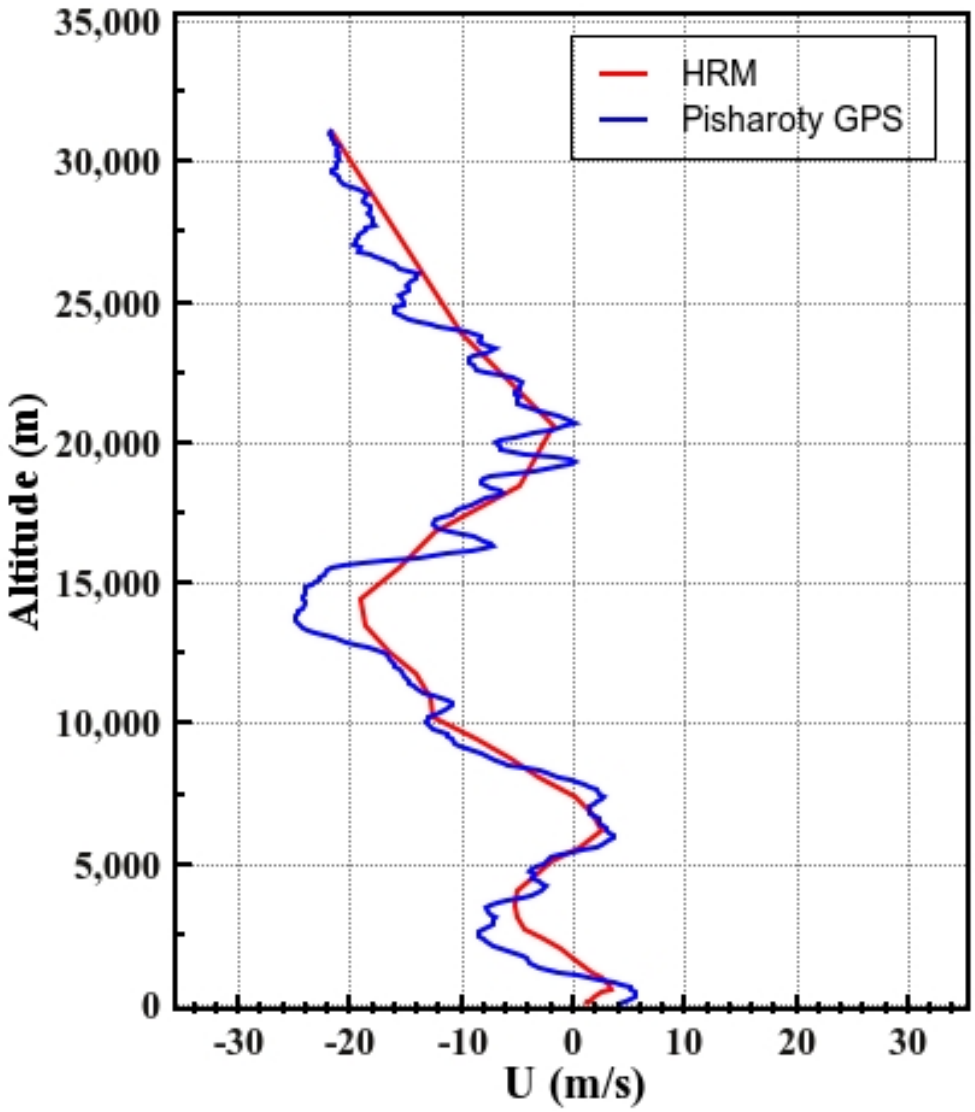


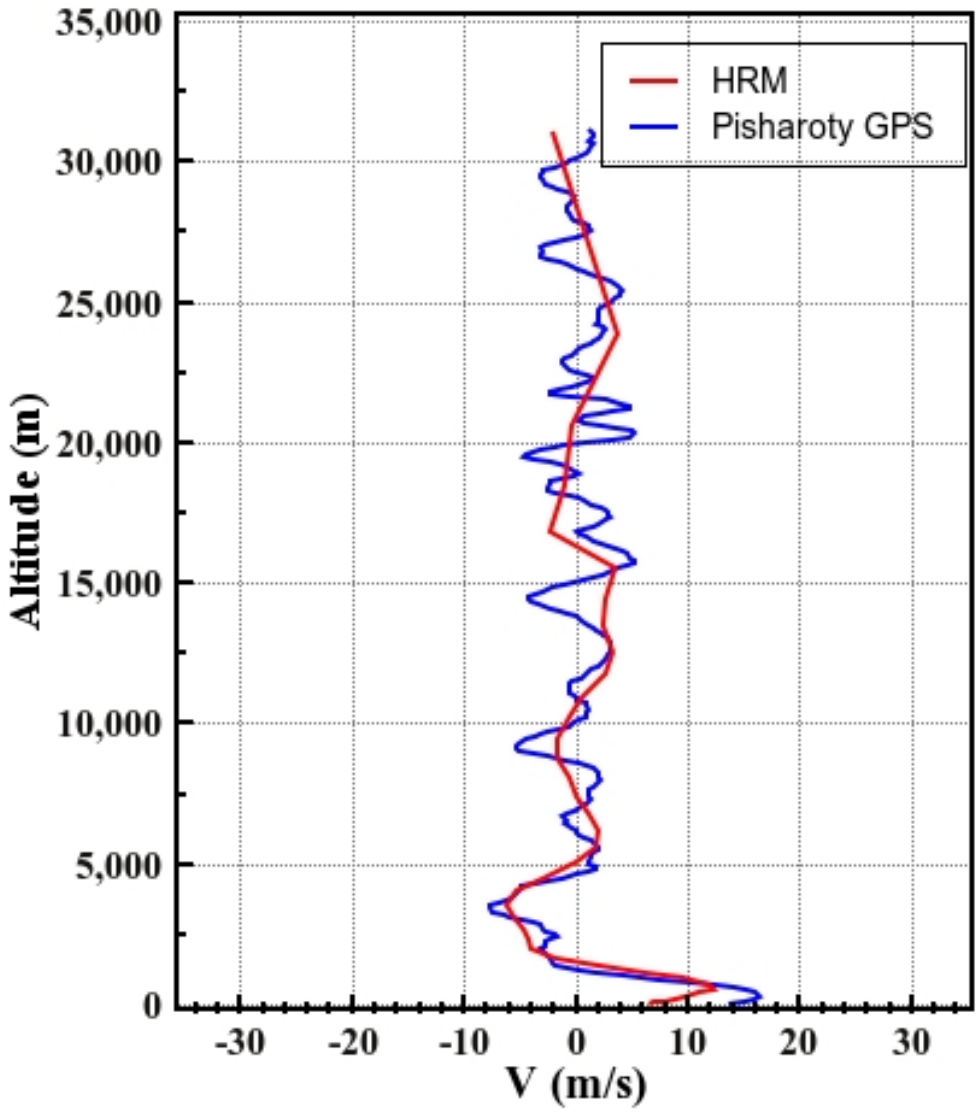
HRM Simulation vs. NCEP-FNL Reanalysis: RH field at 700 hPa





HRM Simulated Wind Profiles vs. Pisharoty GPS Observations over SHAR
+30 Hrs Forecast valid for April 16, 2009 (Vehicle Movement)





Predictions provided By (Institute / Centre):

Space Physics Laboratory, VSSC, Thiruvananthapuram.

Model used:

High-resolution Regional Model (HRM)

Based on Observation: (Date / Time):

Global Model Extended (GME): 15.04.09 (0000 GMT)

Weather prediction issued on date: 15.04.2009 (0530 GMT)

No.	Description	Prediction for the next 48 hrs from the time of observation 00Z 15 April 2009				
		12 hrs	24 Hrs	36Hrs	48Hrs	72 Hrs
1.	Probability of development of low pressure system in Bay of Bengal	Yes	Yes	Yes	Yes (Weak)	-
2.	Probability of cyclone within 200km of SHAR#	Probable/ Weak	Probable/ Weak	Probable/ Weak	Probable/ Weak	
3.	Thunderstorm probability within 50 km of SHAR	Weak	Weak	Moderate	Moderate	
4.	Probability of rain & Intensity (Heavy/Medium / Low) within 50km of SHAR	Low	Low	Trace	Trace	
5.	Visibility	-	-	-	-	
6.	Expected Maximum wind (m/s)	1-5 m/s	1-5 m/s	1-7 m/s	1-8 m/s	
7.	Predicted wind profile (up to 18km ht)/ expected strength of LLJ & TEJ	see profile data	see profile data	see profile data	see profile data	
8.	Trend (improve / deteriorates)	-	-	-	-	

Such an event has given us good confidence in severe weather prediction during launch campaigns and we are working out on our shortcomings for improvements...

Nowcasting at Sriharikota through ARPS Model Simulations for prediction of thunderstorms

[PSLV-C11 (Chandrayaan-1)]

Contributors:

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S. Indira Rani[3], Asish Kumar Ghosh[4]

[1]SPL, VSSC, Thiruvananthapuram

[2]ISRO Technical Liaison Unit, Paris

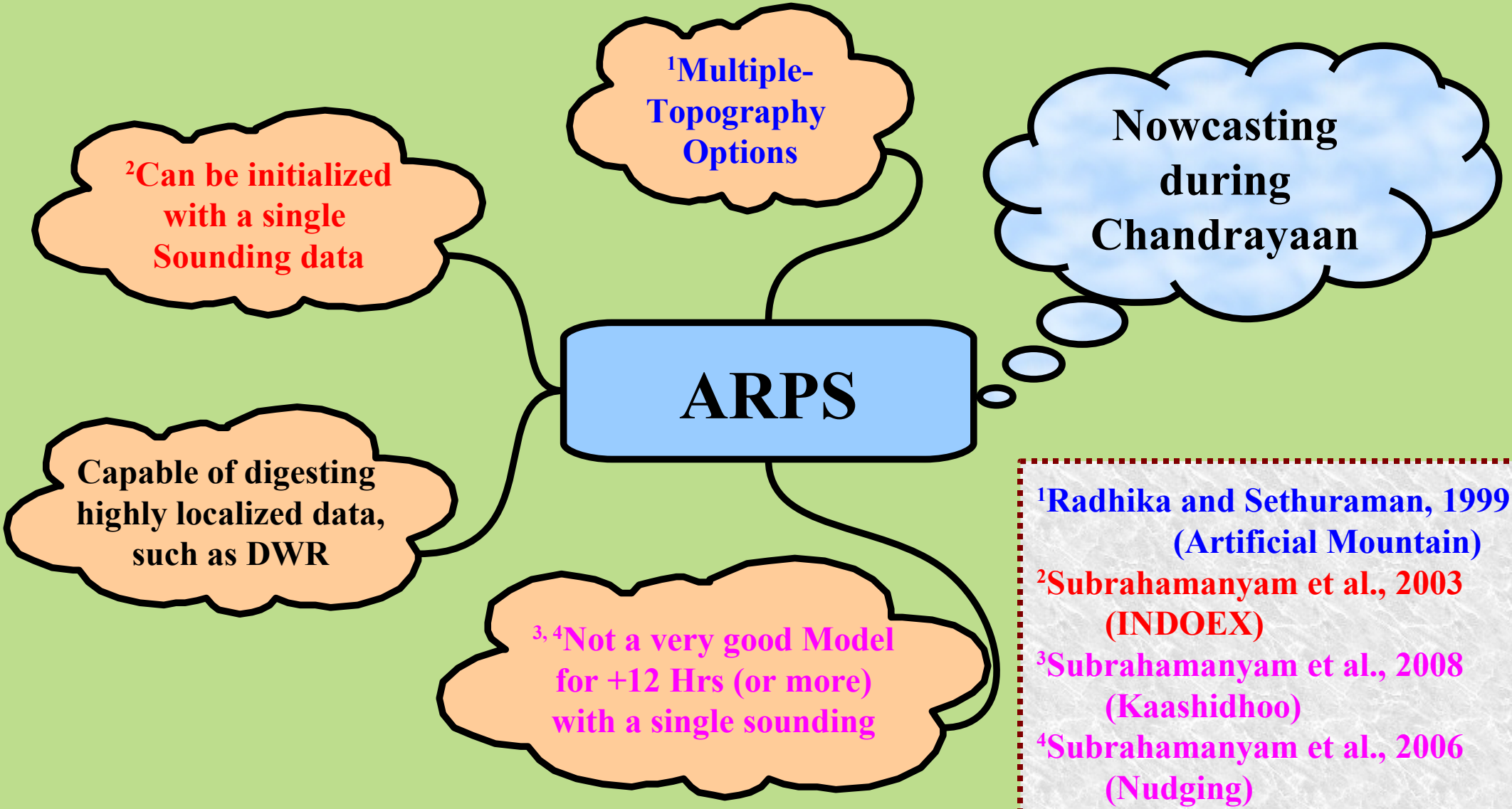
[3]Now at: NCMRWF, Noida

[4]Range Operations, MET Facility, SDSC, SHAR

Advanced Regional Prediction System (ARPS)

Non-hydrostatic Model developed by Centre for Analysis and Prediction of Storms & University of Oklahoma

ARPS Model Simulations at SPL ...



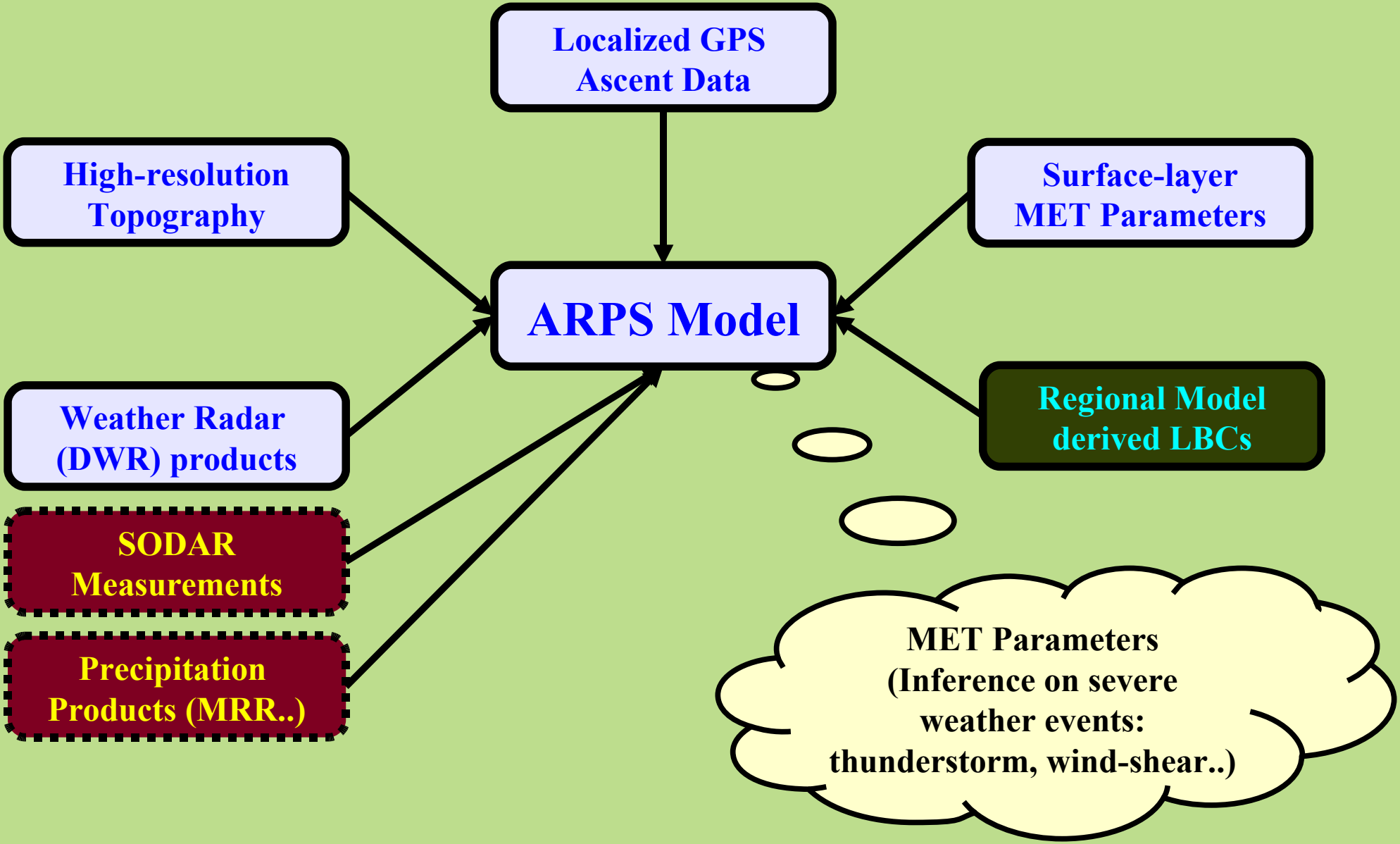
[1]Radhika and Sethuraman, 1999 (Artificial Mountain)

[2]Subrahamanyam et al., 2003 (INDOEX)

[3]Subrahamanyam et al., 2008 (Kaashidhoo)

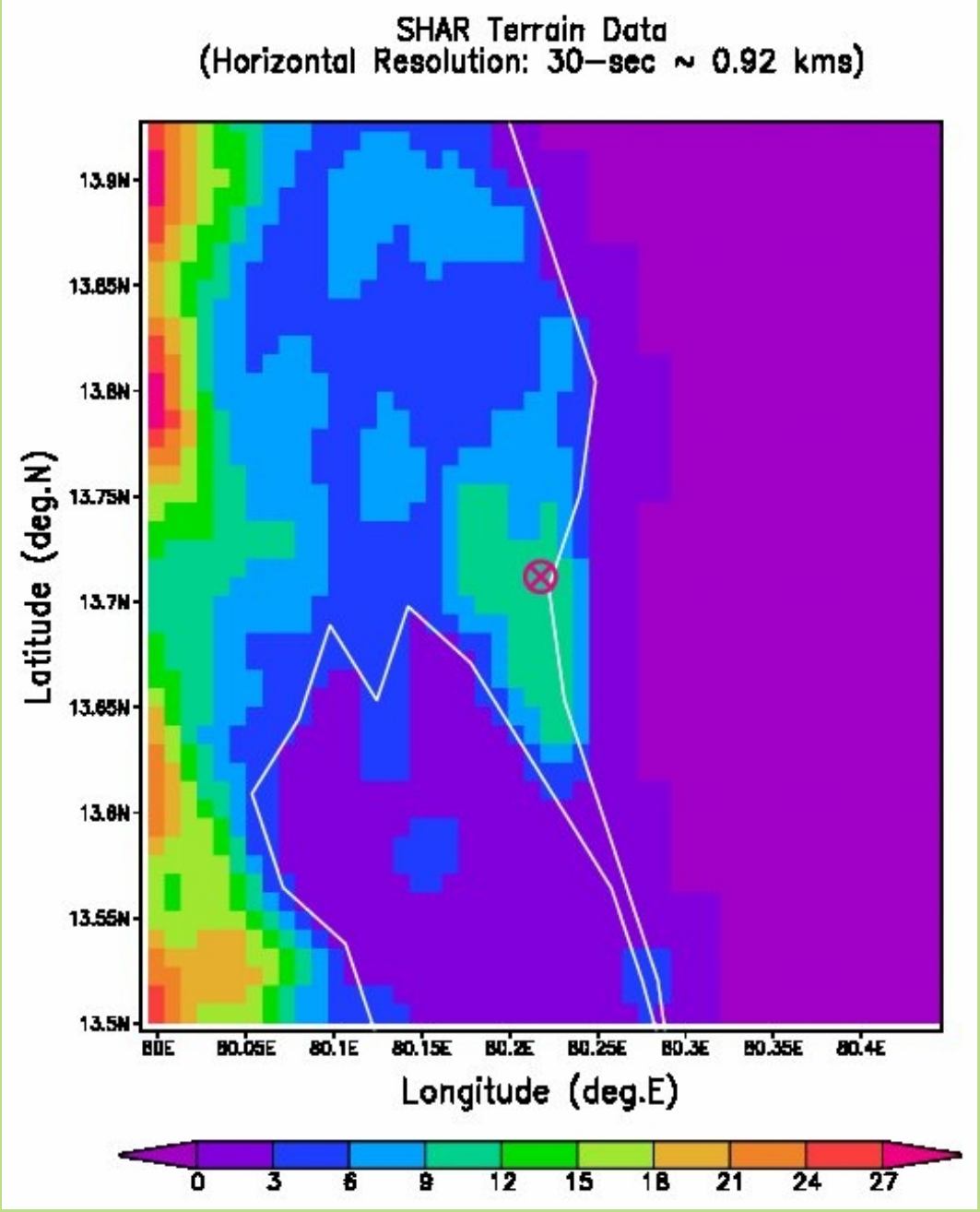
[4]Subrahamanyam et al., 2006 (Nudging)

ARPS Model (Inputs and Outputs)...



SHAR Topography in ARPS Model

(TOPO30 data set from USGS)



Criticalities during Weather Forecasting during Chandrayaan-1 Launch
(Regional Scale ----> Mesoscale ----> Nowcasting)

Highlights during Weather Briefing with Launch Authority Board (LAB):

[T-4 days to T-1 days]

(1) Is there any trace of a cyclonic system advancing towards SHAR ?

(2) Will the next +24 hours will be cloudy or clear sky ?

(3) Are we going to experience unusual high surface winds ?

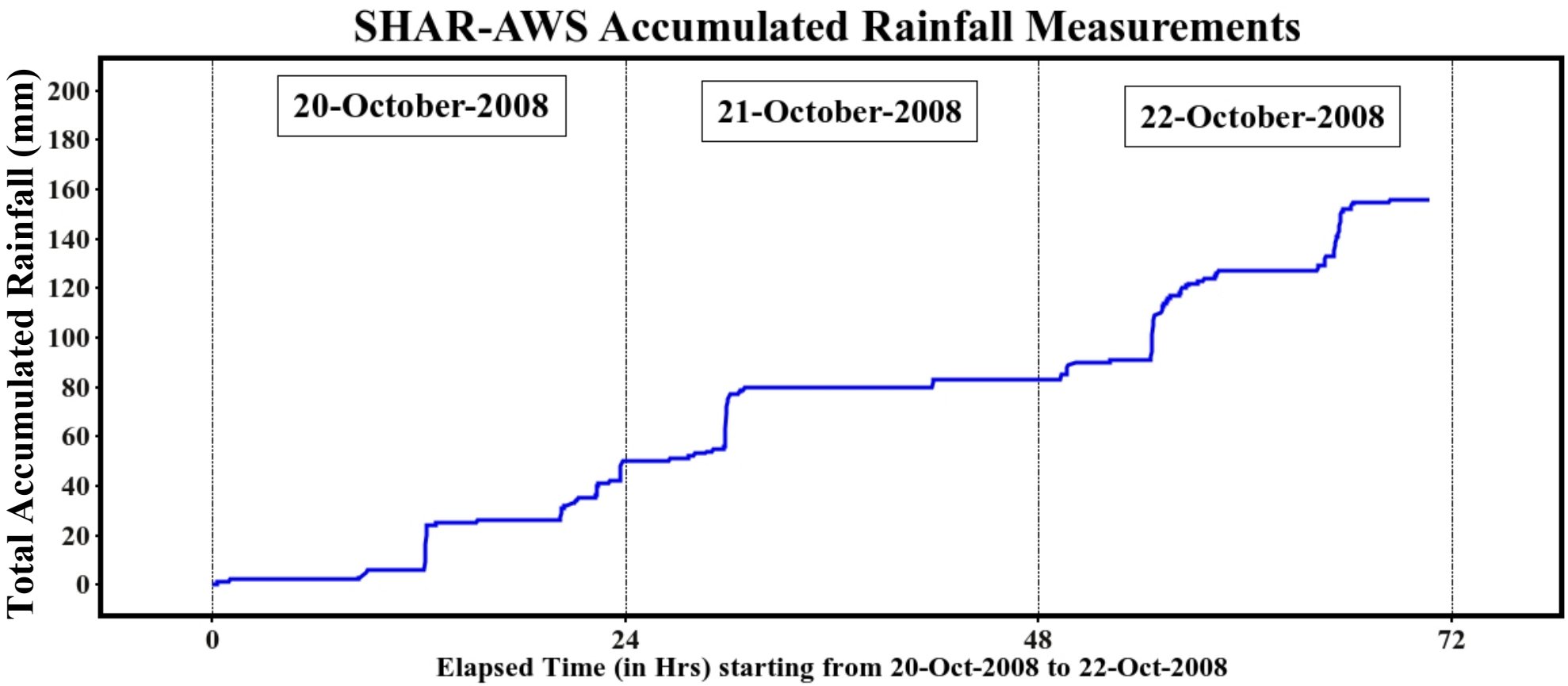
(4) What are the probable time-slots of moderate to heavy rainfall over the launch site ?

.....

[T-1 days to Launch time]

WILL THERE BE ANY THUNDERSTORM IN THE NEXT 6 HOURS ? (YES/NO)

Criticalities during Weather Forecasting during Chandrayaan-1 Launch (Regional Scale ----> Mesoscale ----> Nowcasting).....

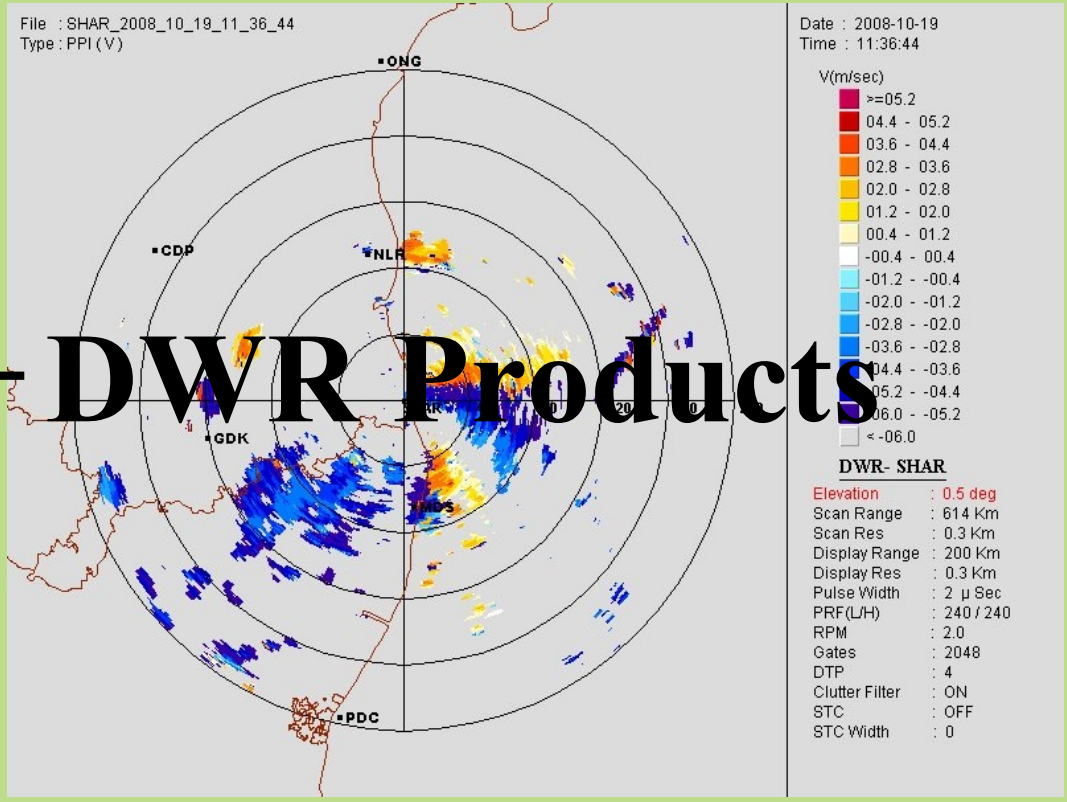


Usage of ARPS Model Products in conjunction with the Doppler Weather Radar (DWR) Products for prediction of Thunderstorm occurrence:

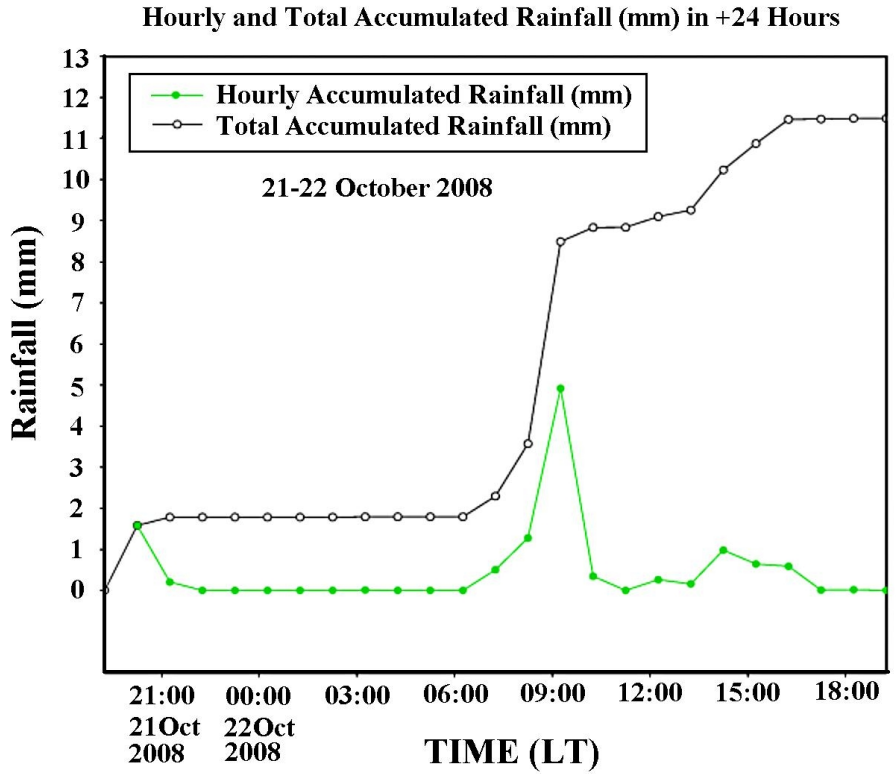
ARPS Products

- Predicted Rainfall
- Low-level wind shear
- Surface layer water vapor content
- Cloud water vapor content
- Vertical velocity

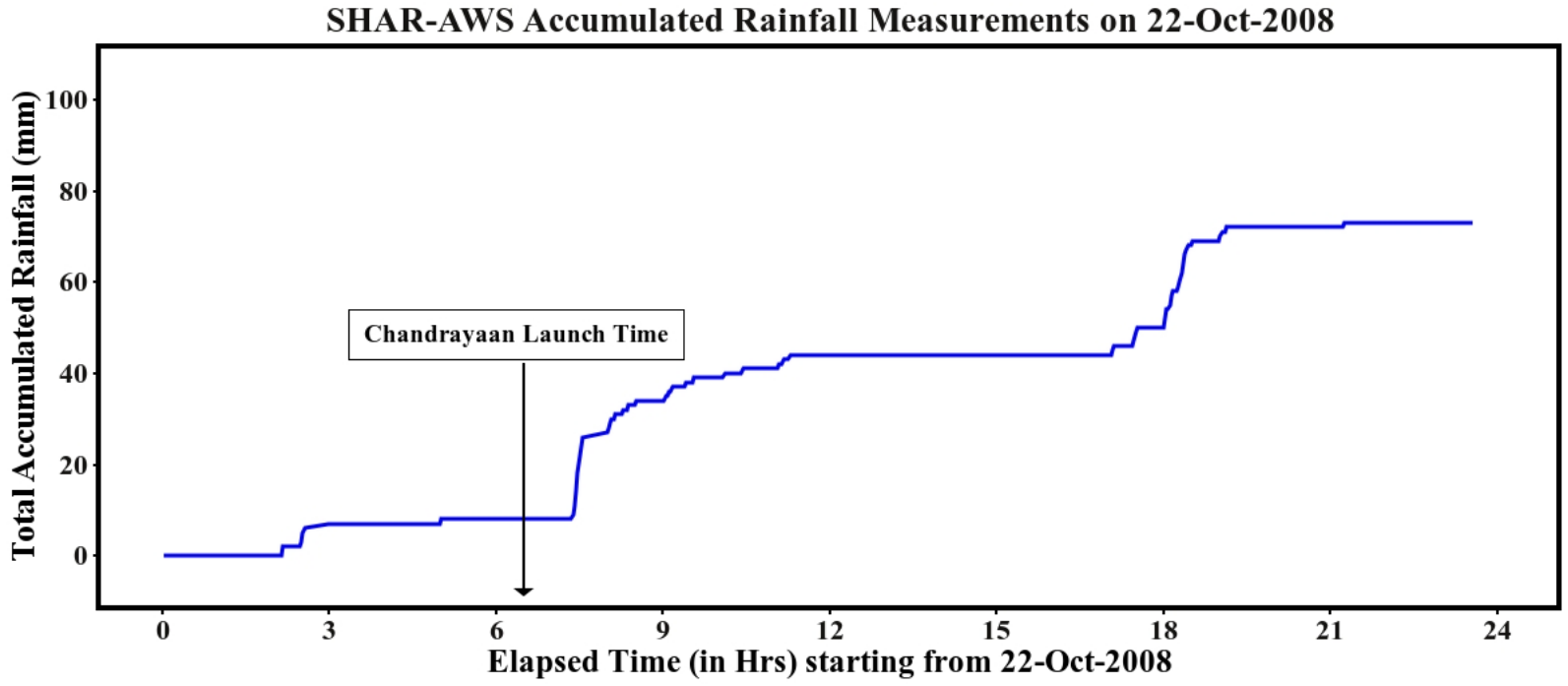
+ DWR Products

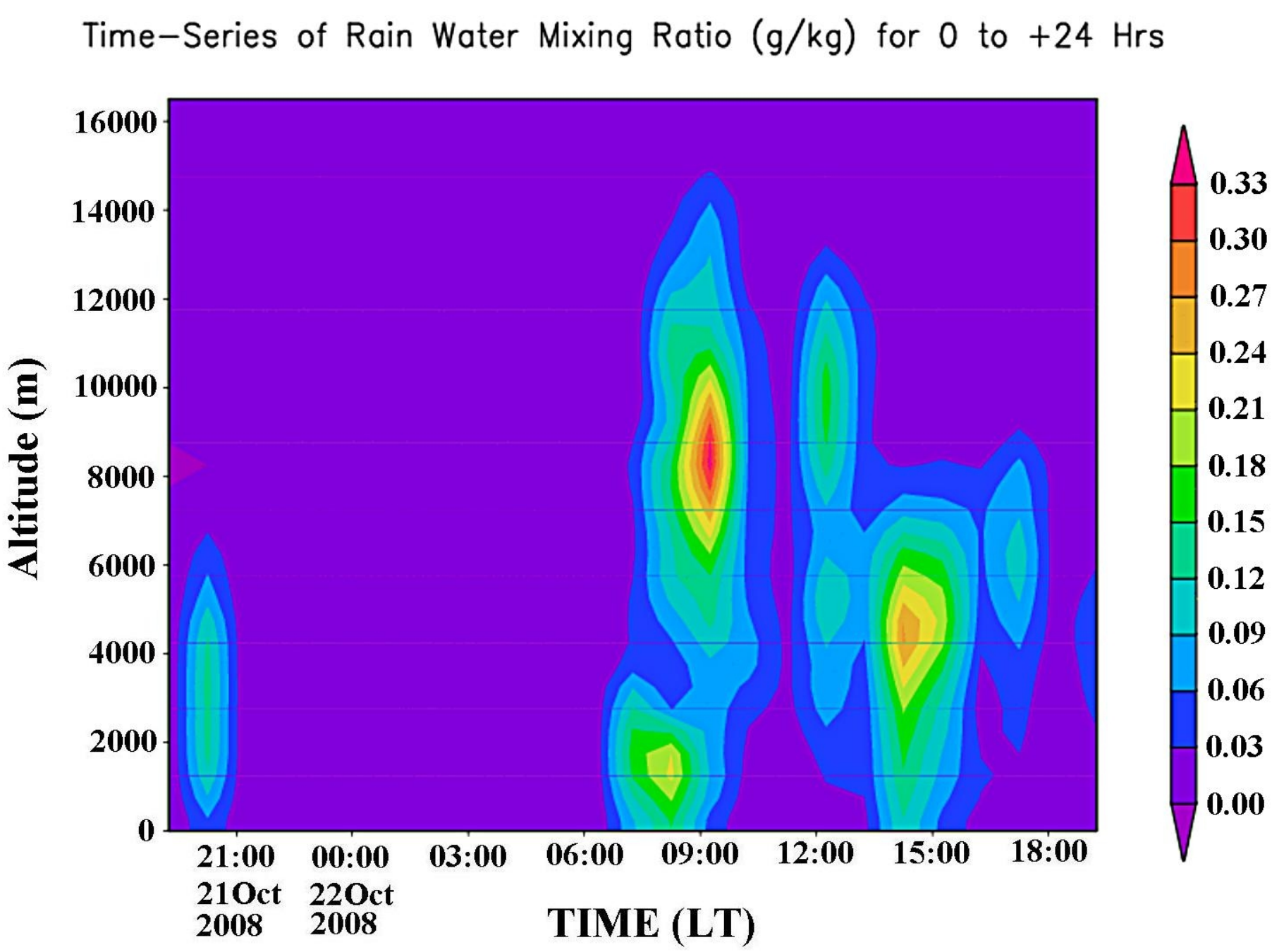


New Index for Thunderstorm (0 - 5)

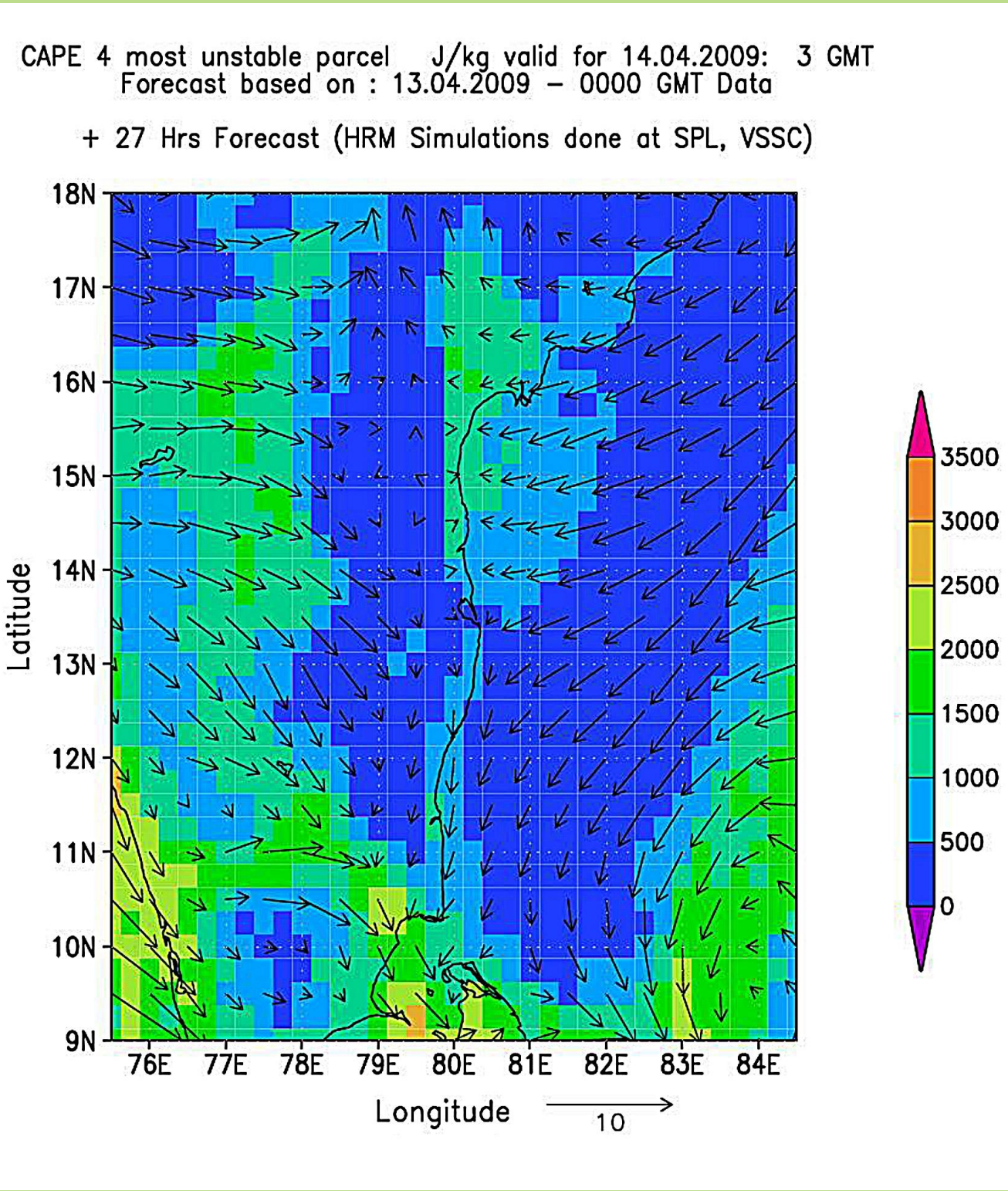


Comparison of ARPS simulated rainfall vs. SHAR AWS rainfall measurements




Time–Series of Rain Water Mixing Ratio (g/kg) for 0 to +24 Hrs
Altitude (m)
16000
14000
12000
10000
8000
6000
4000
2000
0
21:00
21Oct
2008
00:00
22Oct
2008
03:00
06:00
09:00
12:00
15:00
18:00
TIME (LT)
0.33
0.30
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0.00

HRM Simulated CAPE values for the most unstable parcel during PSLV-C12 Vehicle movement stage: CAPE < 2500 J/kg indicating feeble chances of thunderstorm



ARPS Predictions for Thunderstorm (Mission Chandraayan)
GPS Ascent: 20.10.2008 (0300 LT)

Date	*Time (LT)*	*Rain*	*LLWS*	*Qv*	*Qc*	*w*	*Forecast*	
20.10.2008	0400 LT	1	1	0.5	0	1	3.5	
20.10.2008	0500 LT	1	1	1	1	1	5	
20.10.2008	0600 LT	1	1	1	1	1	5	
20.10.2008	0700 LT	1	1	0.5	1	1	4.5	
20.10.2008	0800 LT	1	1	0.5	1	1	4.5	
20.10.2008	0900 LT	1	1	0.5	1	1	4.5	

- Rain = accumulated rainfall (spread over domain, mm/hr)
- LLWS = low-level-windshear (visual observation from U & V profiles)
- qv = water vapor content (g/kg)
- qc = cloud water vapor content (g/kg)
- w = vertical velocity (cm/s)

Forecast was regularly being updated every +6 hours with the latest GPS ascent

Factors Considered for providing the forecast:

Arbitrary Index Values (least favourable=0; most favourable=1)

- **Predicted Rainfall (0-1)**
- **Low-level wind shear (0-1)**
- **Surface layer water vapor content (0-1)**
- **Cloud water vapor content (0-1)**
- **Vertical velocity (0-1)**

Arbitrary Scaling : 0 – 5 (min – max range)

Confidence Level is shown in % in brackets

0 to 2.5	**: No Thunderstorm**	**(> 90%)**
2.5 to 3.5	**: Low Rainfall, but no thunderstorm**	**(> 75%)**
3.5 to 4.0	**: Moderate probability of thunderstorm**	**(> 70%)**
> 4.0	**: Very high probability of thunderstorm**	**(> 80%)**

Concluding Remarks from "Atmospheric Modelling Activities for Location Specific (SHAR) Forecasting....."

- ➔ Effective Usage of HRM and ARPS for local weather prediction over SHAR
- ➔ Validation of HRM Simulations with FNL Reanalysis and Kalpana Satellite Imagery
- ➔ Alteration in Cloud Parameterization scheme for improving cloud cover simulation in HRM
- ➔ Inference of HRM simulated parameters in providing threat in terms of cyclonic storms over SHAR
- ➔ New Methodology (Five-parameter dependent index based on ARPS products) for thunderstorm prediction.....

Characterization of "Marine Atmospheric Boundary Layer (MABL)" during W-ICARB Ship-borne Field Experiment

Cruise Participants:

D. Bala Subrahamanyam, N. V. P. Kiran Kumar,

S. S. Prijith, Sherine Rachael John,

Land-Segment Participants:

P. K. Kunhikrishnan, Mannil Mohan, S. Sijikumar, Sandhya K. Nair,

Santosh Muraleedharan, S. Indira Rani, Denny P. Alappattu, Marina A.

Thanks are also due to:

C. B. S. Dutt, K. Krishnamoorthy, S. Suresh Babu, S. Satyanarayana,

Subbarao and Punaram Sinha (TIFR-BF, Hyderabad) & all participants

Objectives of the 'MABL' component of W-ICARB

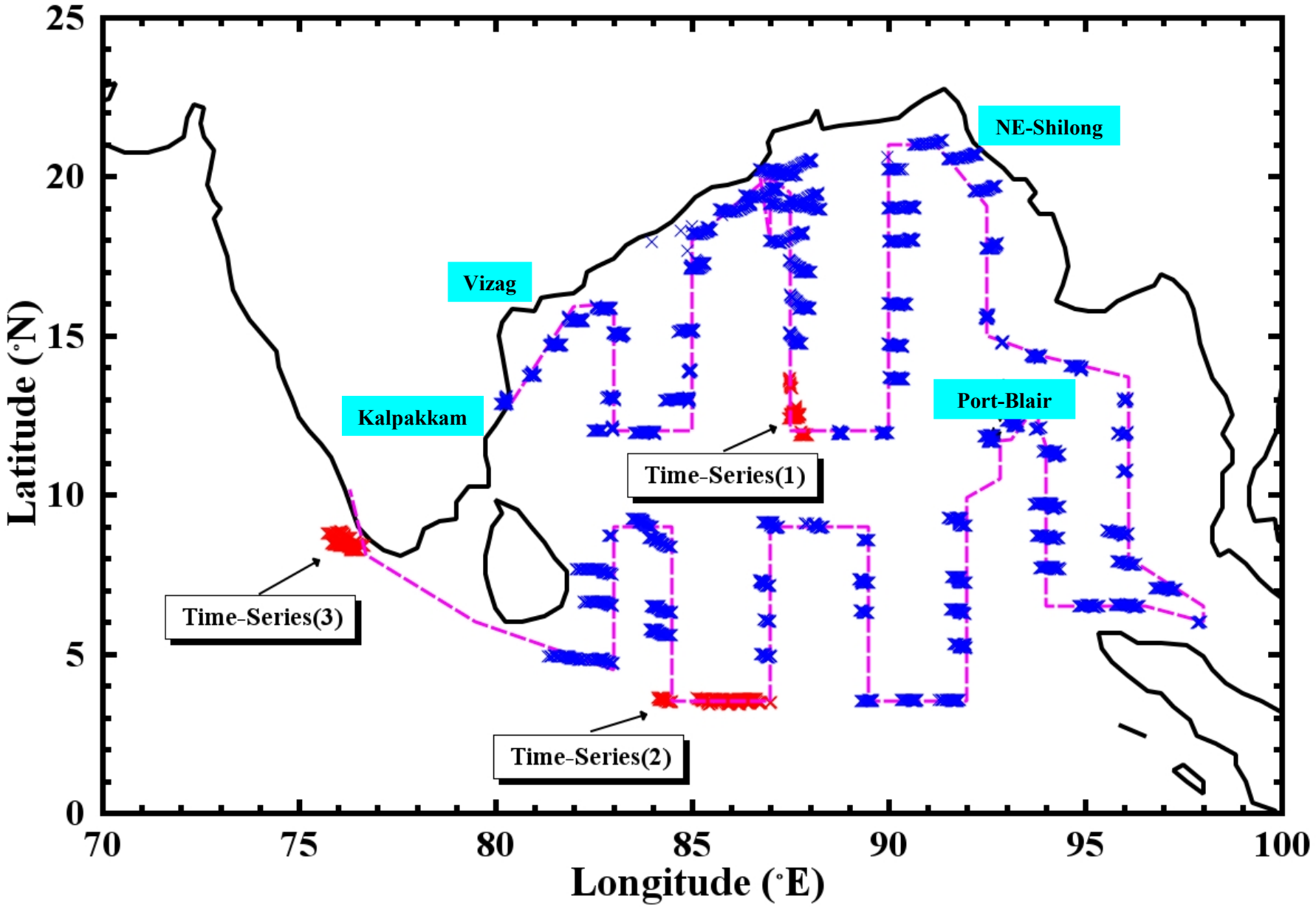
Characterization of MABL over the Bay of Bengal during winter monsoon through:

- Delineation of different layers in vertical within the MABL
- Diurnal variation in MABL evolution during time-series measurements
- Coupling of air-sea interaction parameters with vertical structure of the MABL
- Estimation of surface layer turbulent fluxes through Bulk Aerodynamic & profile method
- Investigation of sea/land breeze circulation over Thumba Coast through concurrent time-series measurements over ship and coast
- Tropopause dynamics over BoB and its plausible linkage with MABL features

W-ICARB MABL Component Database

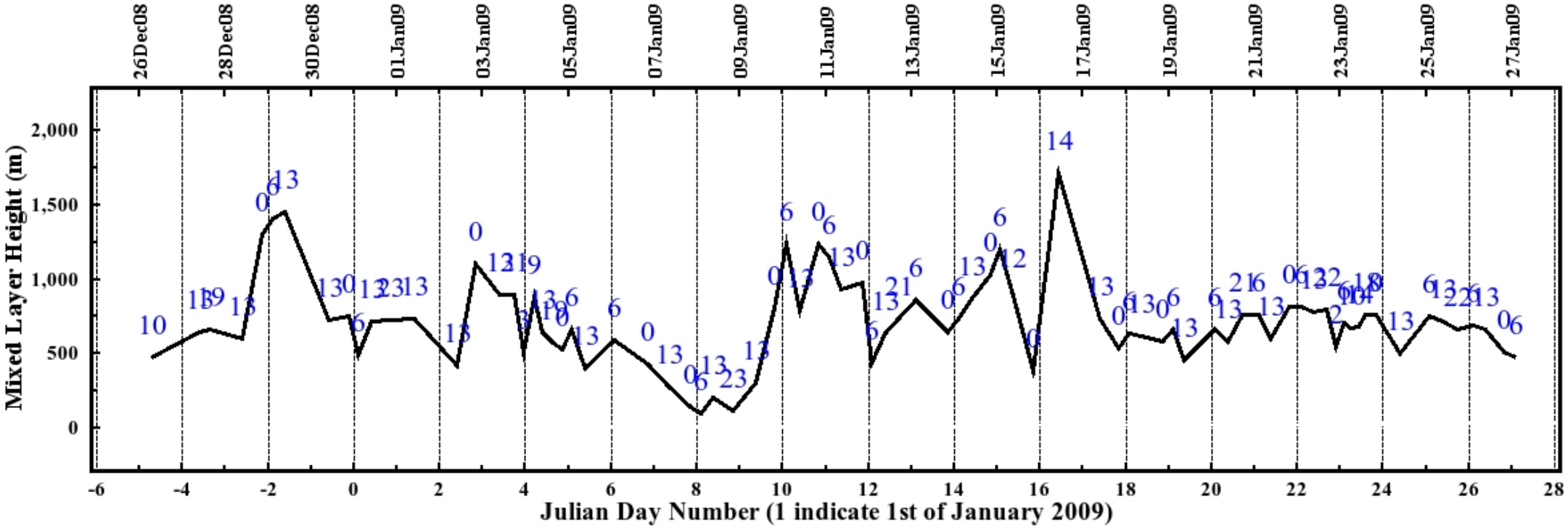
- ✓ Upper Air meteorological observations through Pisharoty GPS Sonde (108 Nos.)
- ✓ Retractable-boom mounted surface layer meteorological measurements
- ✓ Manual meteorological and SST measurements
- ✓ ....

Pisharoty Sonde Trajectory during ICARB-W (SK-254) Cruise
Red symbols indicates 'time-series measurements'

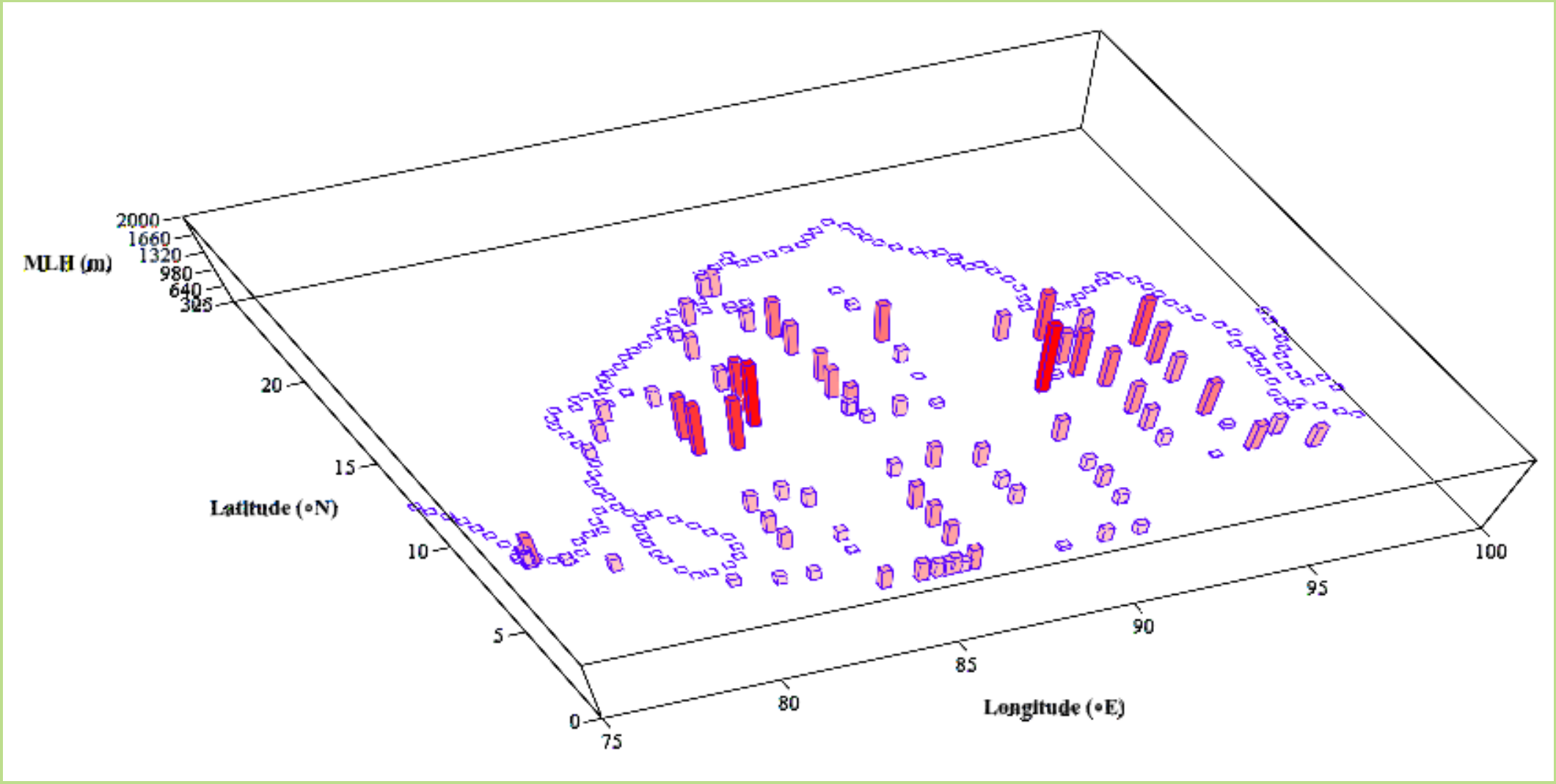


Spatio-temporal variability in mixed-layer heights over BoB during W-ICARB

The labels on the curve indicate the local time of the balloon-ascent

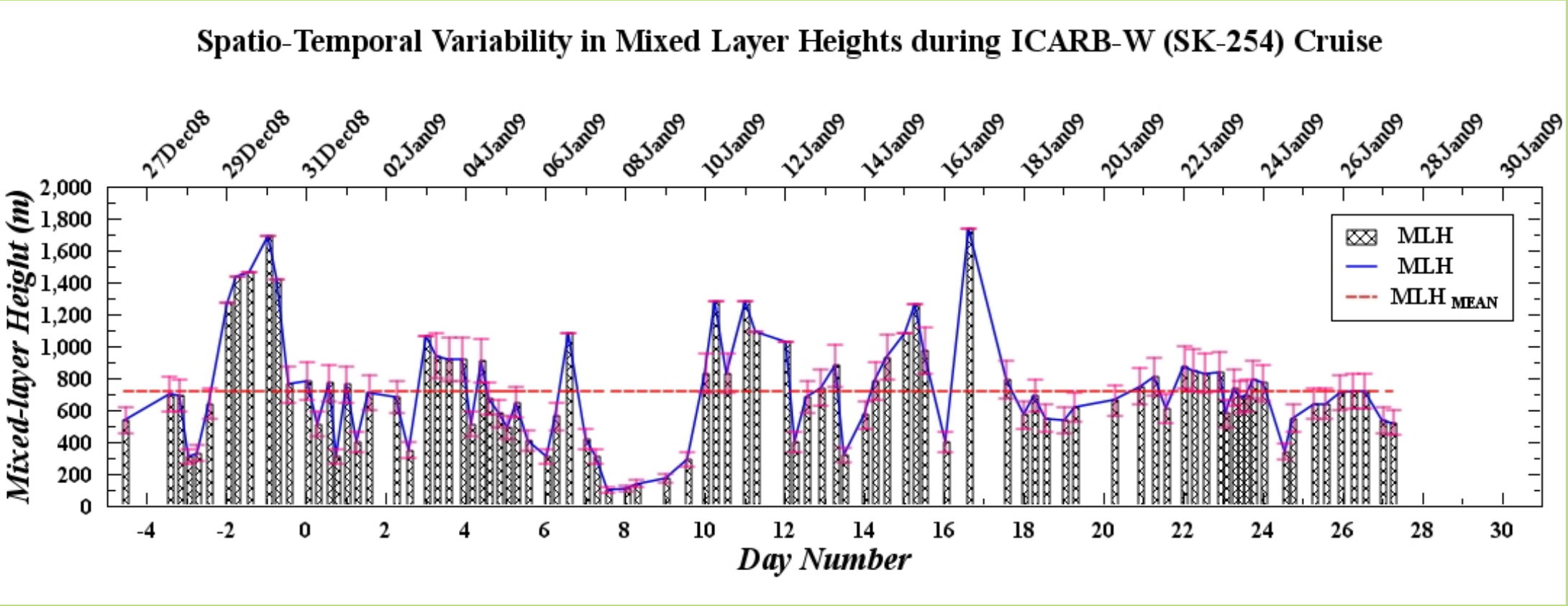


Spatio-temporal variability in mixed-layer heights over BoB during W-ICARB

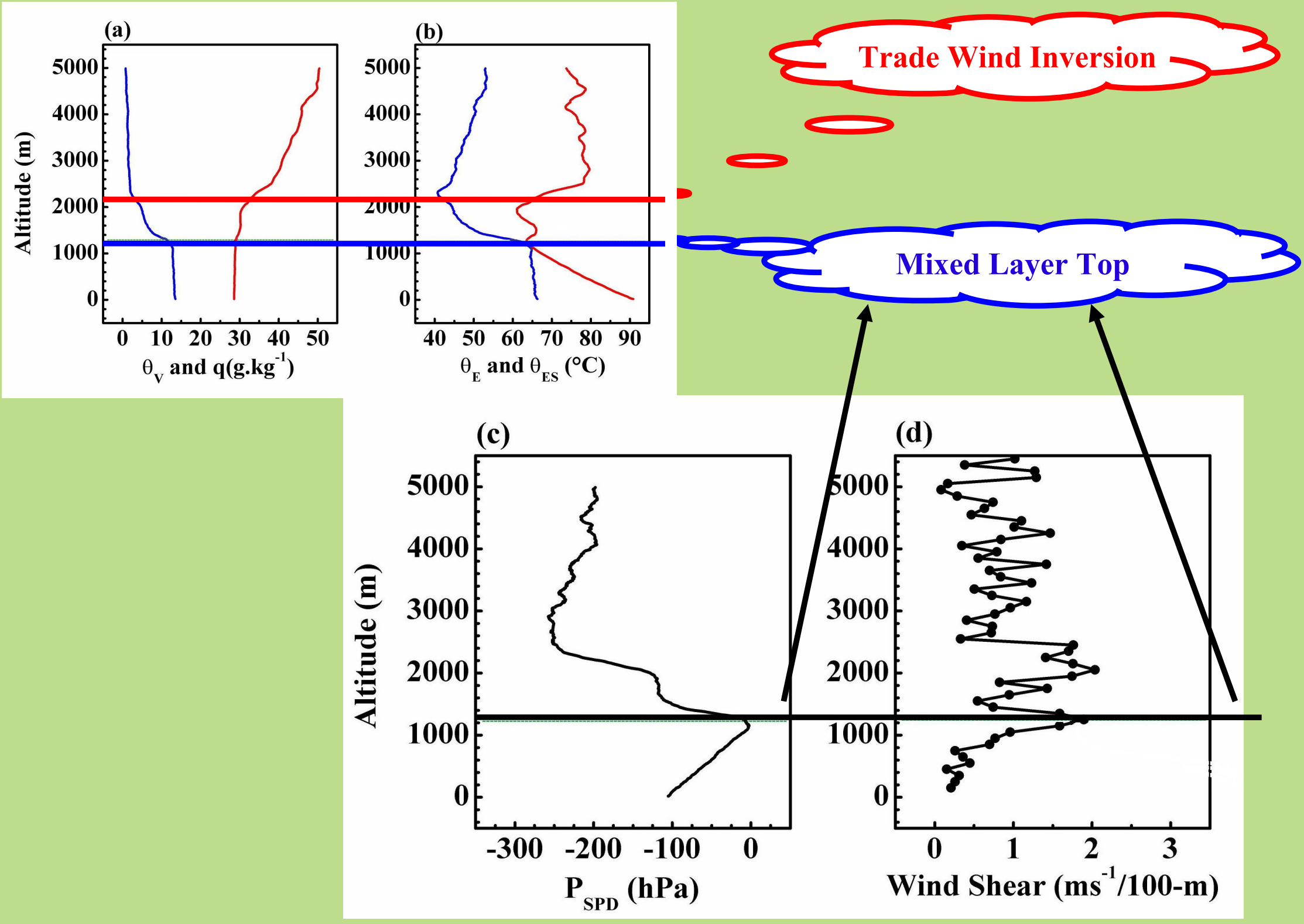


Marginally High values of Mixed Layer Heights over BoB during W-ICARB compared to previous cruises...

(Mean MLH > 700 m; higher than that over Thumba !!!)



What could be the possible dynamics behind high values of mixed layer heights ?.....


(a)
(b)
(c)
(d)
Altitude (m)
5000
4000
3000
2000
1000
0
0 10 20 30 40 50
θV and q(g.kg-1)
40 50 60 70 80 90
θE and θES (°C)
-300 -200 -100 0
PSPD (hPa)
0 1 2 3
Wind Shear (ms-1/100-m)
Trade Wind Inversion
Mixed Layer Top

Concluding Remarks from "Characterization of the MABL during W-ICARB....."

- ➔ Role of mechanical wind-shear in formation of deep mixed layer extending up to ~ 1.5 kms over BoB
- ➔ In general, high MLH over northern BoB as against southern BoB
- ➔ On an average, mean MLH during the entire cruise is significantly higher (more than that over Thumba)
- ➔ .....

Monsoon Onset over Kerala through Systematic Horizontal Advection (MOKSHA) – Pilot Campaign: An Overview

Contributors:

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P. K. Kunhikrishnan and Mannil Mohan (Thumba Segment)

Special thanks are also due to:

S. Satyanarayana et al., RFAFD, VSSC

SNOM, Cochin Naval Base, Cochin

Objective of MOKSHA Campaign

As the SW-monsoon sets over the Kerala and advances northward, it brings enormous moisture (in turn enhancing the rainfall over the sub-continent). MOKSHA aims at investigating the horizontal advection of moisture over the Kerala Coast (in Pilot phase) through systematic observations and regional atmospheric modelling with a special emphasis on its impact on the "Atmospheric Boundary Layer".

MOKSHA: Approach

Regular Pisharoty GPS Ascent (~10 – 15 days centered around the SW-monsoon onset dates) from Thumba and Cochin

HRM, WRF and ARPS will be used for simulation of moisture intrusion into different altitudes

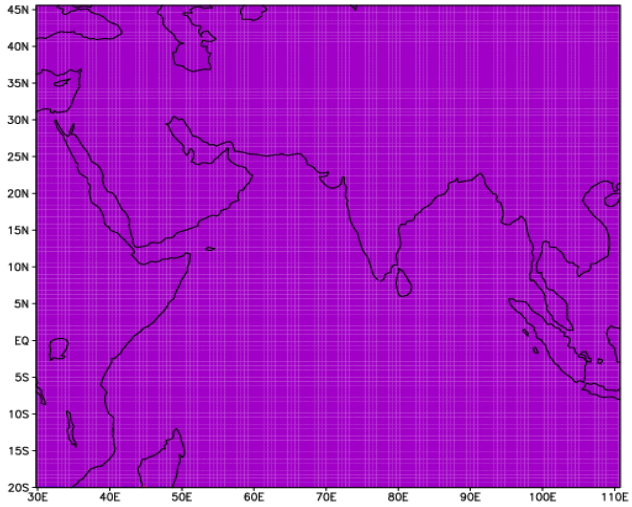
Observational evidence on the impact of moisture intrusion on the ABL...

Effects of regional forcings on interannual variability of Indian summer monsoon: Regional Climate Modeling (A New Initiative)

S. Sijikumar, SPL, VSSC

The ICTP Regional Climate Model (RegCM 3): Experimental Setup

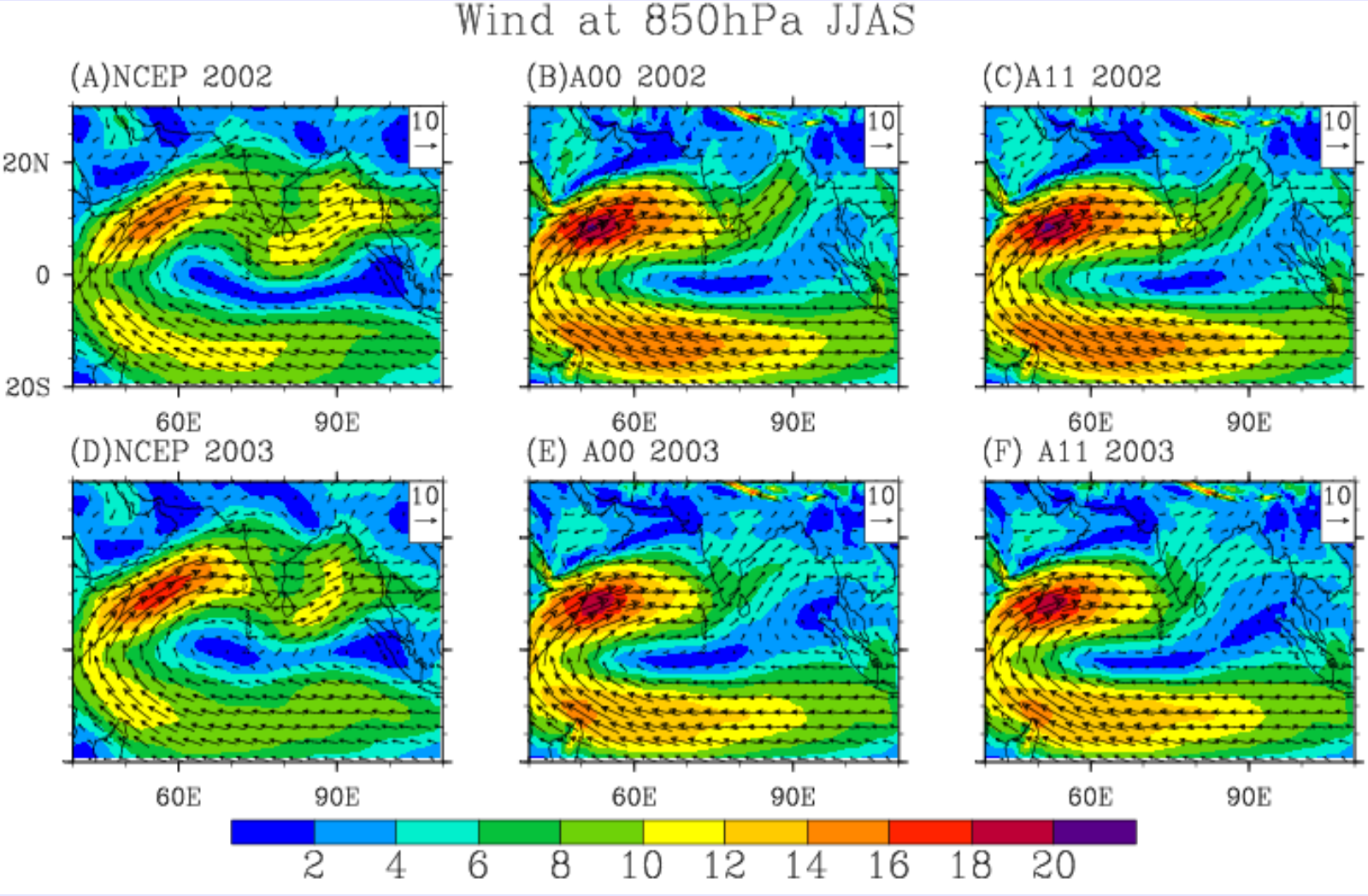
Model Domain: (25 S – 45 N; 30E – 110E)
Horizontal Resolution: 60 Kms
Model Top: 50 hPa (~20.5 Kms)
Model intergration time-step: 150 sec
Model is forced through NCEP/NCAR Reanalysis



As an initial sensitivity studies, two modelling experiments were designed for two consecutive monsoon seasons (1May - 30Sep): 2002 (deficient monsoon) and 2003 (normal monsoon)

(1) A00: Without any chemistry coupling
(2) A11: With chemistry part included in the model

Reanalysis **No Chemistry** **With Chemistry**

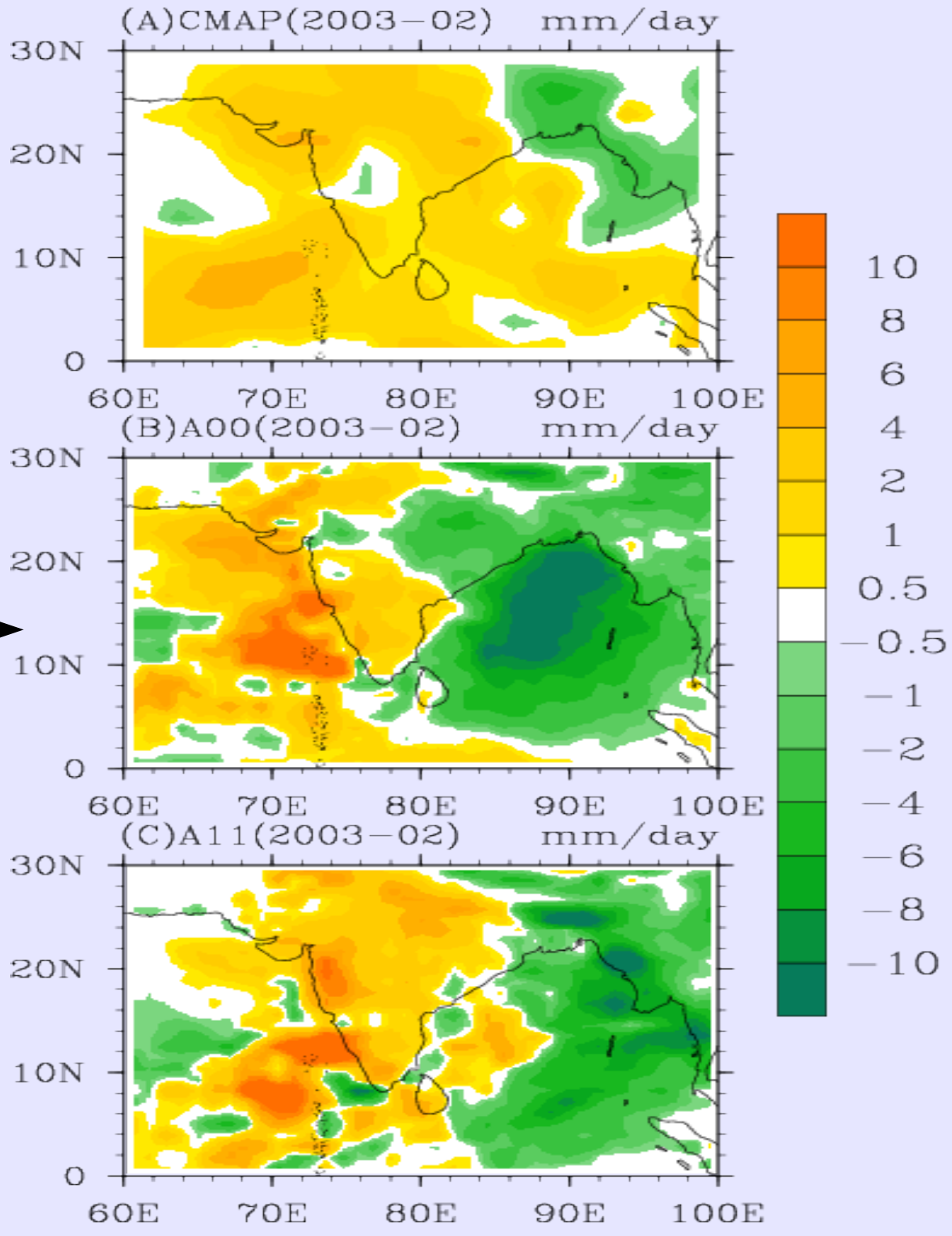


Preliminary Conclusion: Chemistry part in RegCM did not affect significantly in monsoonal wind pattern simulation...

Reanalysis

No Chemistry

With Chemistry (Significant changes are seen ....)



Thanks for
Your Patience