South Asian Precipitation: A Seamless Assessment: SAPRISE

NERC/MoES funded project

Changing Water Cycle Programme

Pis: Krishna AchutaRao
Mat Collins

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Partner Institutions and Scientists

1: IIT, Delhi: Prof Krishna AchutaRao, Dr Sagnik Dey
2: Univ. Exeter: Prof Mat Collins, Dr Indrani Roy
3: ICCSIR, Gujarat: Dr Vikram M. Mehta, Dr Satyendra Bhandari, Dr Bhashi H. Vaid, Mr Dhaval Prajapati
4: IITM, Pune: Dr K. Ashok, Dr. Jayasree Revadekar, Mr. Sudhir Sabade
5: IIT, Kanpur: Prof S.N. Tripathi
6: IIT, Kharagpur: Prof P.C. Pandey, Dr Mihir Kumar Dash
7: IMD: Dr D.R. Pattanaik
8: Met Office Hadley Centre: Dr B. Bhaskaran, Dr Alberto Arribas, Dr Viju John, Dr Richard Levine, Dr Gill Martin, Dr Sean Milton, Dr Jane Mulchay
9: NCMRWF: Dr E.N. Rajagopal, Dr Raghu Ashrit, Dr Gopal Iyengar, Dr Ashis K. Mitra, Dr John P. George
10: Univ. Reading: Dr Andy Turner, Prof Richard Allan, Prof Ellie Highwood

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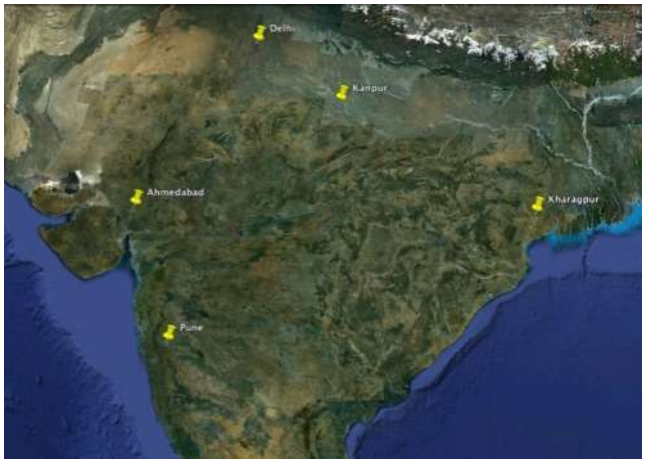
Partner Institutions and Scientists




Kick Off Meeting Pune in Feb 2012


Exeter Meeting June 2013


Delhi Meeting July 2014

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Scientific Objectives

- To ***investigate driving processes, variability, predictability and forced changes*** in South Asian precipitation ***on multiple time scales***.

- A key focus will be on ***interactions with the Indian and remote ocean basins*** and on the local and remote interactions with the ***dynamic and radiative effects of aerosol.***

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Specific Objectives

1. Investigate ***processes*** responsible for ***present day mean, variability and change in South Asia precipitation*** and test the ***ability of state-of-the-art climate models*** to simulate this. **Work Package – 1**
2. Evaluate the ***skill of initialized experiments in predicting*** South Asia precipitation variability and ***investigate mechanisms for predictability.*** **Work Package – 2**
3. Investigate ***changes in South Asia precipitation*** and its ***drivers and interactions in a changing climate.*** **Work Package – 3**
4. Provide a ***seamless assessment and syntheses*** of results to advance our ***understanding of variability, predictability and change*** in ***precipitation in South Asia***. **Work Package - 4**

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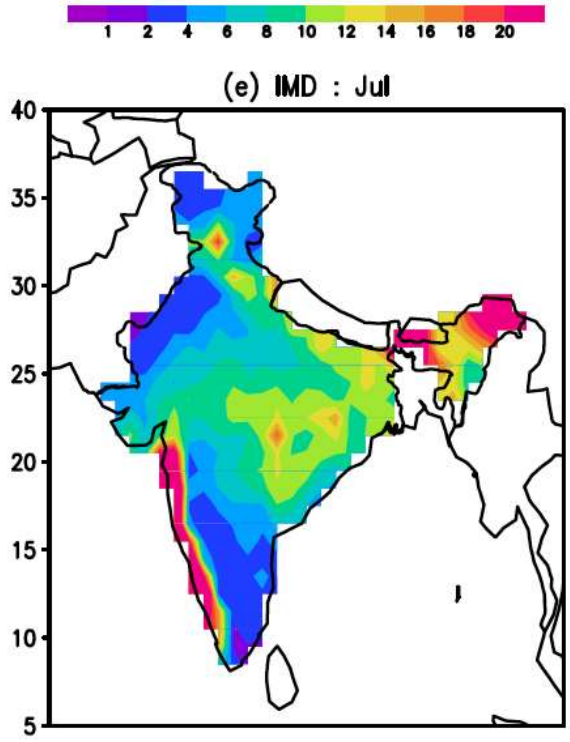
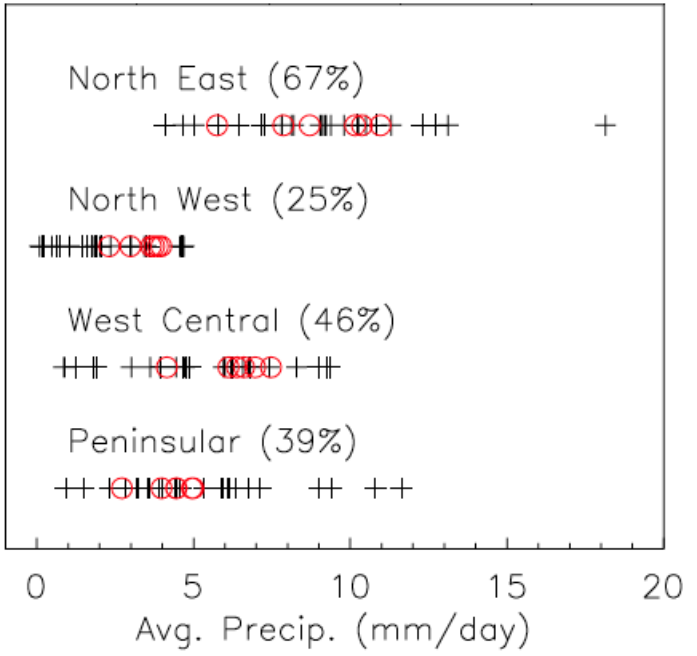
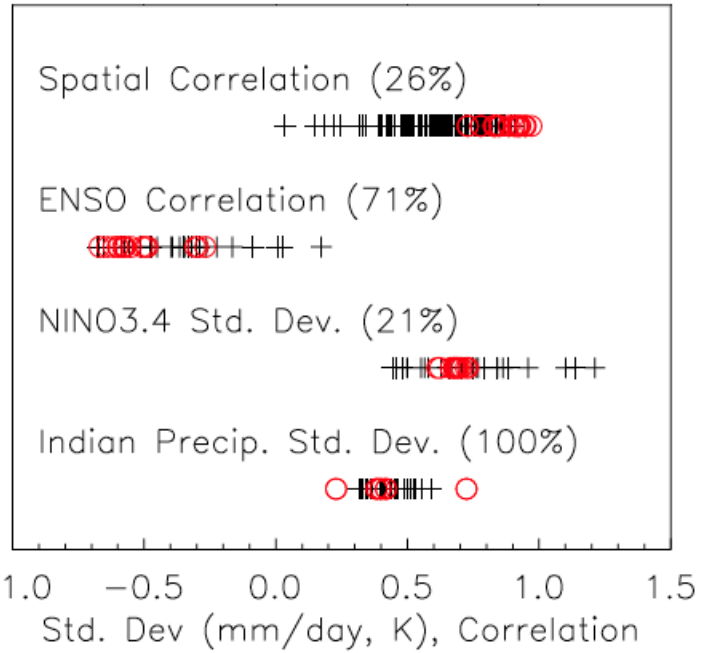
Observational Challenges







Collins, AchutaRao, Ashok, Mitra, Prakash, Srivastava, Turner, Observational challenges in evaluating climate models, Nature Climate Change, 2013

Understanding and evaluating monsoon processes in the MetUM

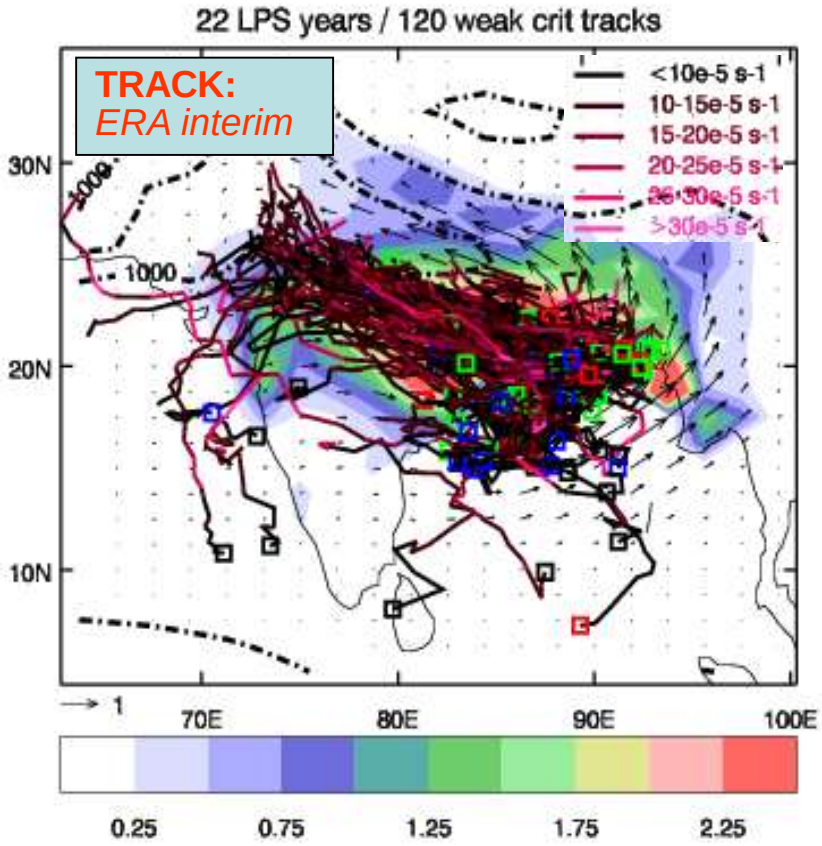
Gill Martin[1], Richard Levine[1], Stephanie Bush*, Nick Klingaman*

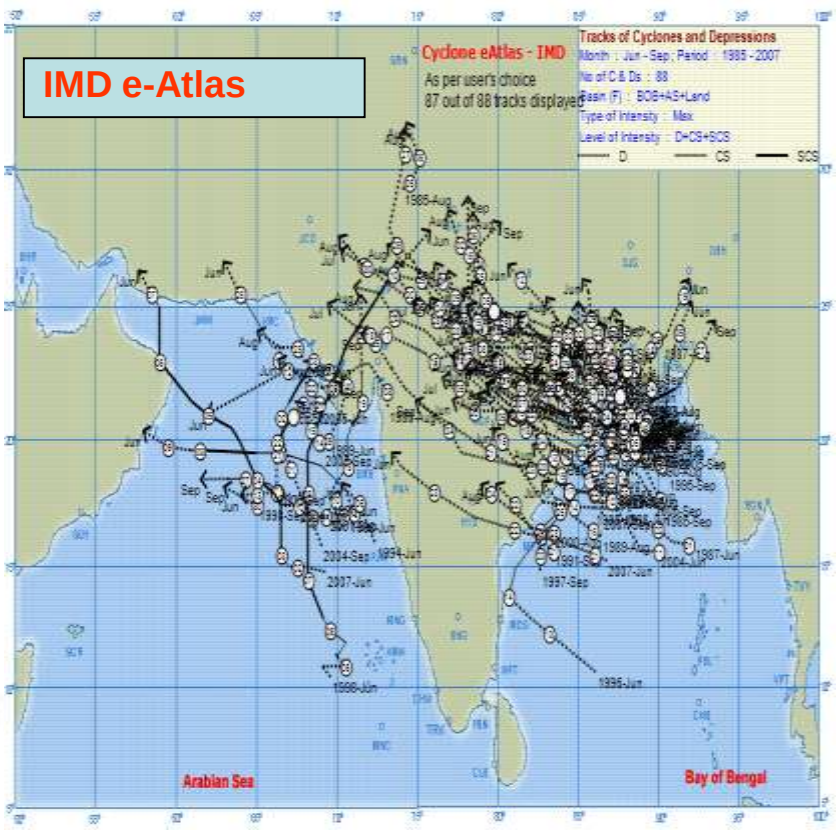
[1]Met Office Hadley Centre
*NCAS-Climate, University of Reading, UK

Monsoon depressions and lows diagnosed in ERA interim re-analysis compared to IMD e-Atlas of MDs and TCs

Met Office Hadley Centre

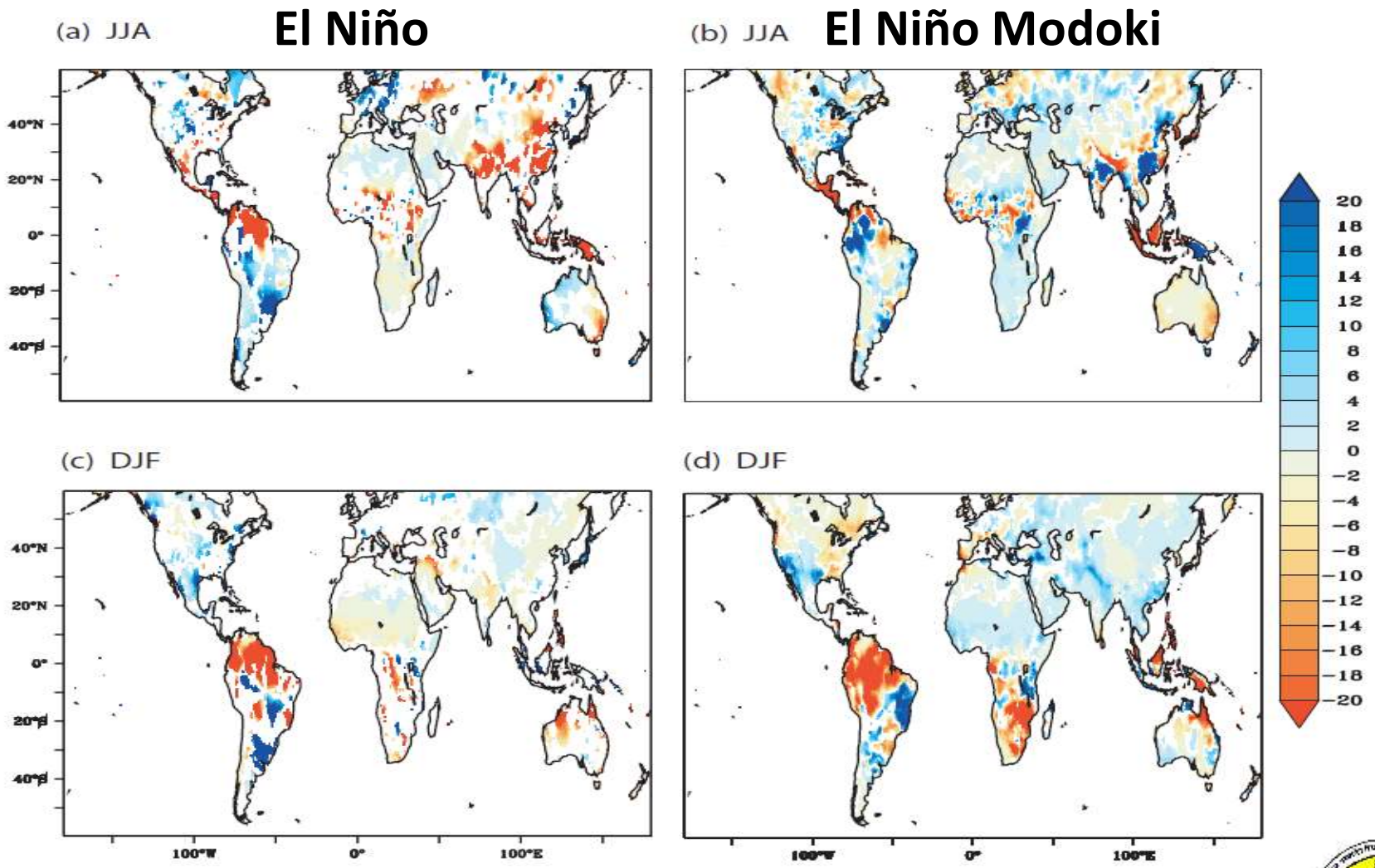
Richard Levine





Method picks up ***most*** monsoon depressions and ***stronger*** monsoon lows (not included in IMD e-Atlas), however, difficulty diagnosing stationary systems in N Bay of Bengal / NE India

Distinct Teleconnections

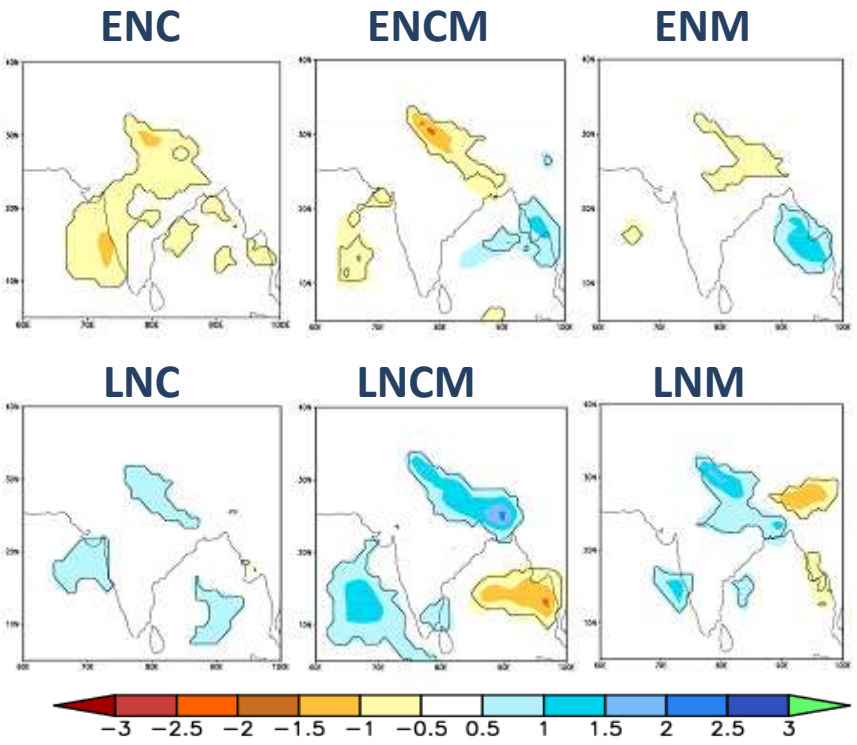


Result Summary: **Seasonal teleconnections of El Niño Modokis and El Niño are distinctly different and not subject to the inclusion of big El Niño events.**

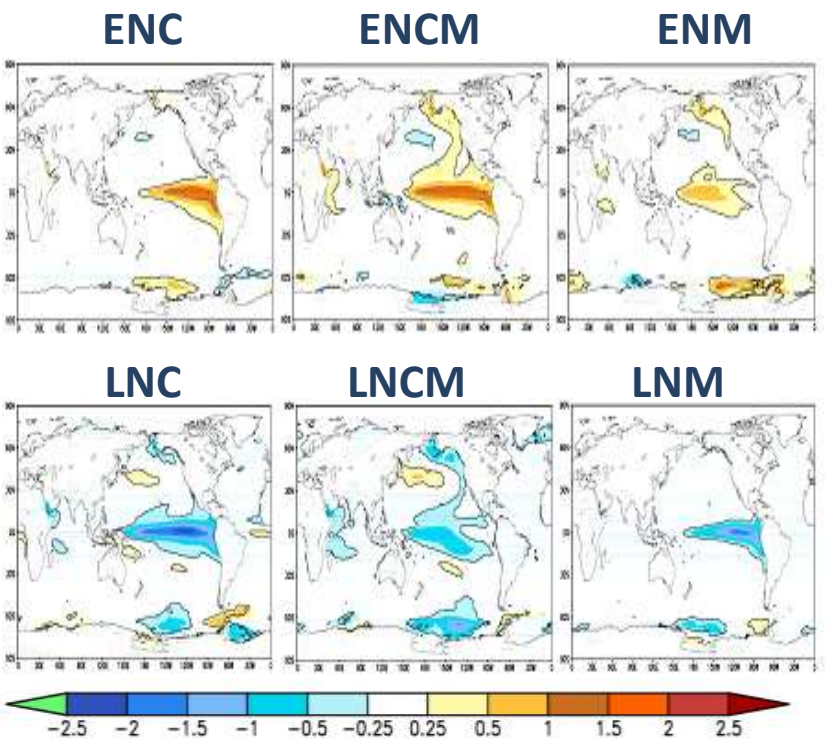
Marathe et al. 2015, Climate Dynamics

Model ensemble of ISM and SST

Ensemble-Precipitation

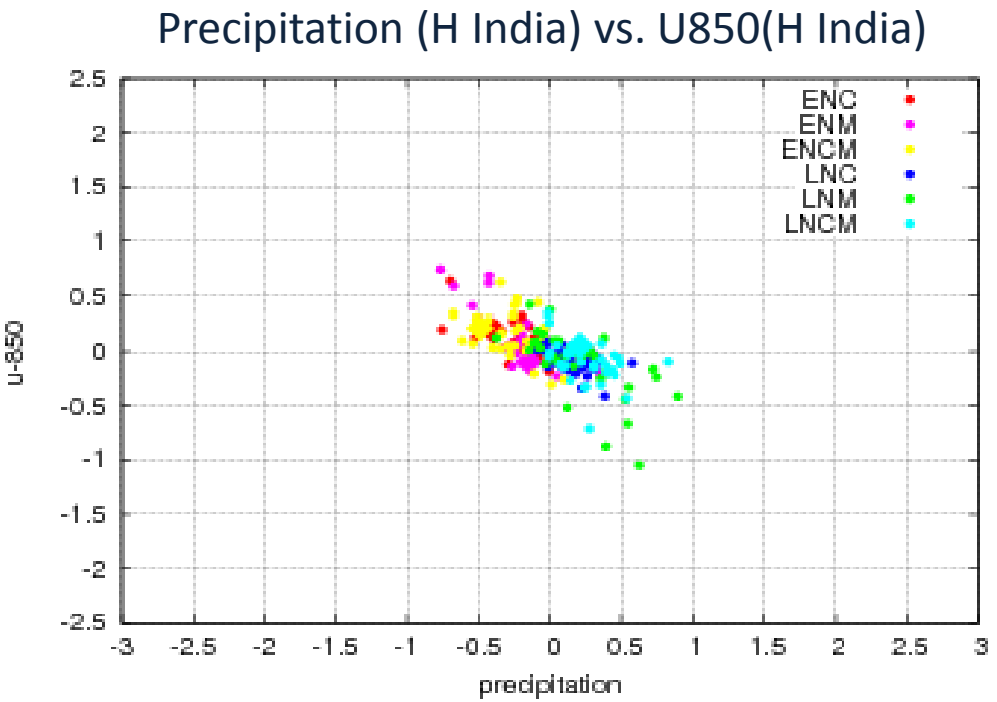


Ensemble-SST



Clear connection (anti-correlation) between tropical Pacific SST and ISM around central NE India matching observation. [Roy, Tedeschi and Collins, IJC, 2016, under revision]

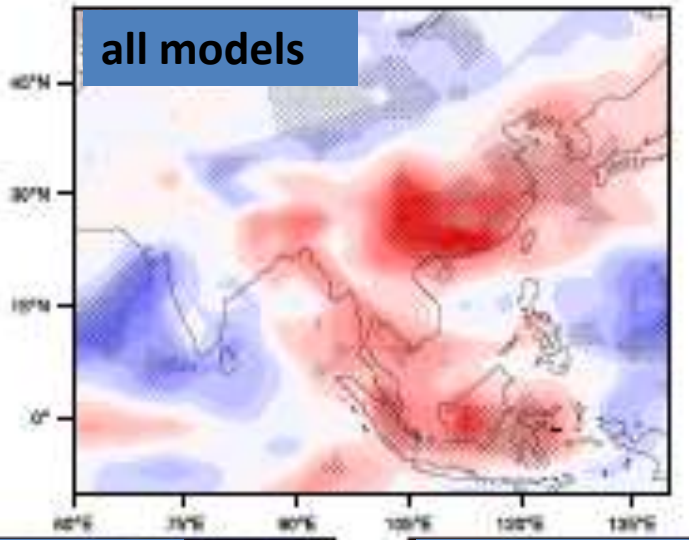
Local Influence on Regional (Hilly Region) Precipitation



- **La Niña in general more precipitation, El Niño less.**
- **During El Niño, U850 is positive, For La Niña it is negative. Indicate change in direction of Walker circulation.**
- **CMIP5 models show strong correlation among models in all El Niño and La Niña phases (c.c. = -0.72). [Roy and Tedeschi, Atmosphere, 2016]**

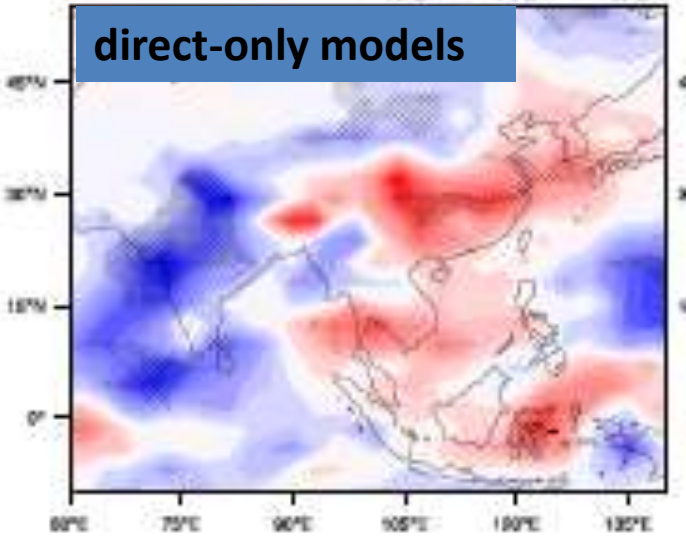
Comparison of indirect and direct-only model groups: late C20th minus PI

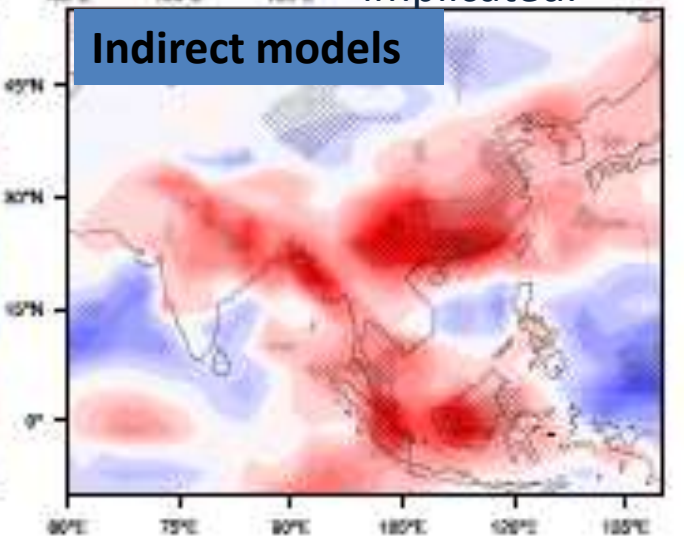
- Common signal of declining rainfall in E/SE Asia
- Increase of South Asian monsoon in direct-only models suggests GHG dominance

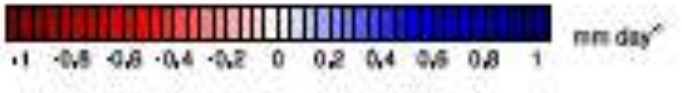


Guo *et al.* (2013, *ACP*) showed 2000 aerosol emissions to have decreased EASM since 1950s; both indirect and direct effects implicated.

- Reinforces importance of indirect effects on South Asian monsoon





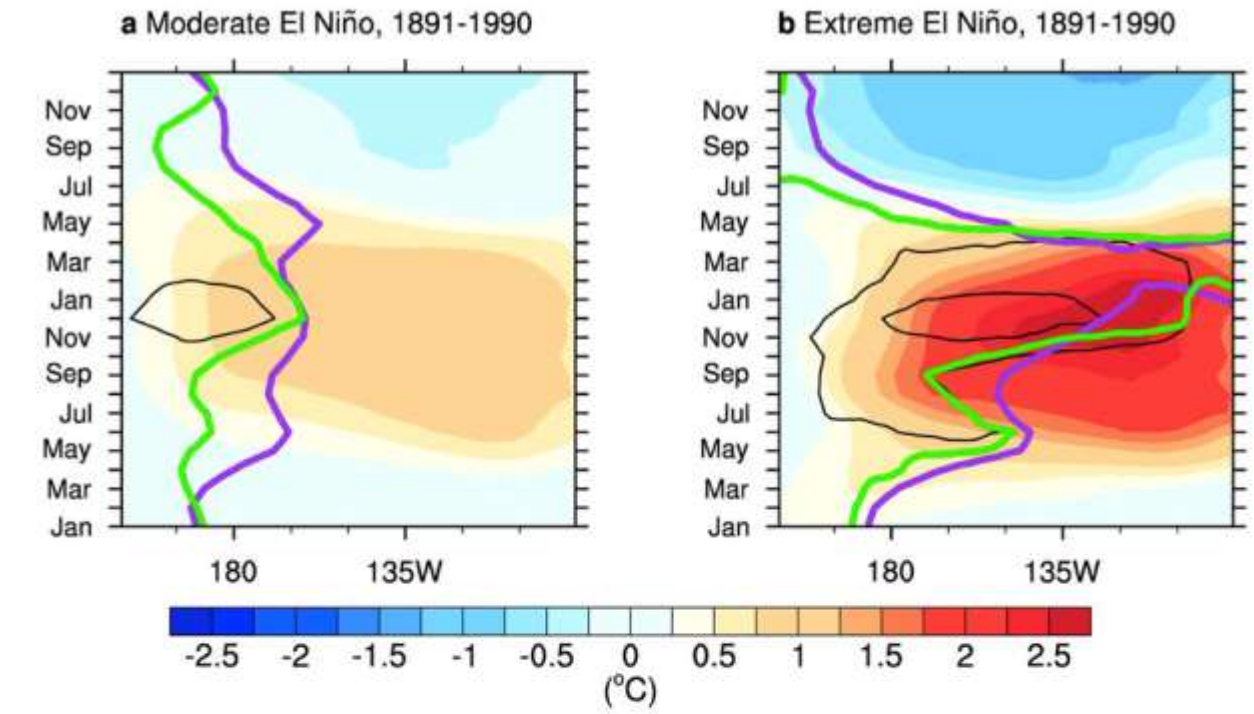


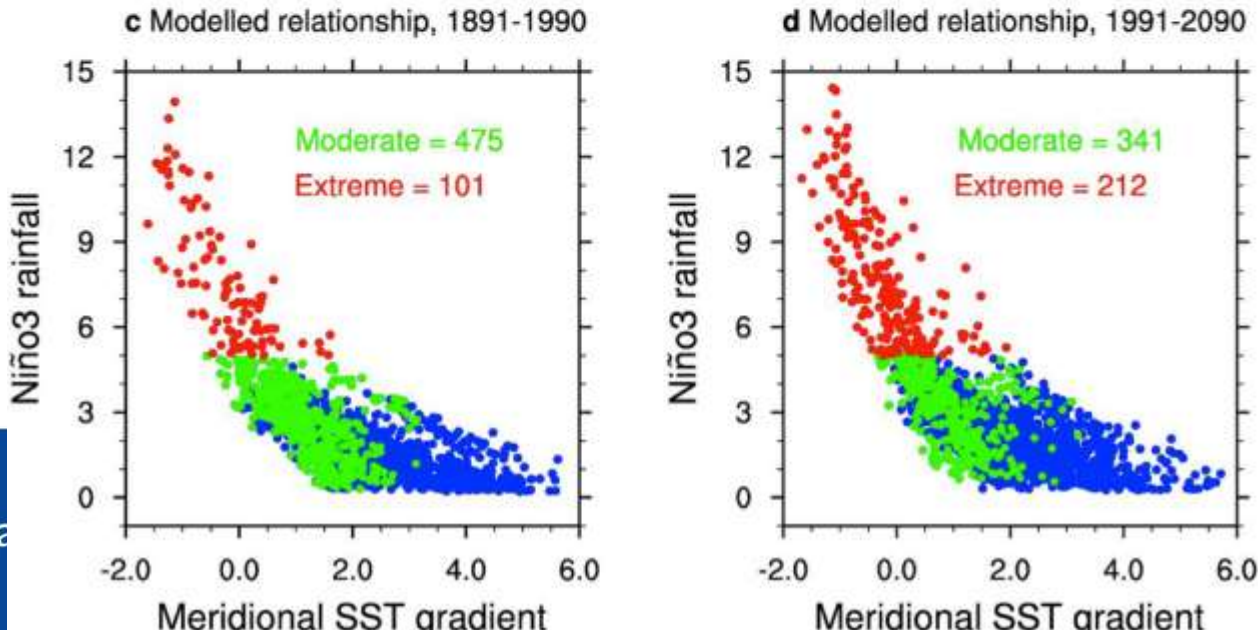
University of Reading

Guo, Turner, Highwood (2015, *ACPD*)

Extreme El Niños

Cai, Borlce, Lengaigne, van Rensch, Collins, Vecchi, Timmermann, Santoso, McPhaden, Wu, England, Guilyardi, Jin. Increasing frequency of extreme El Niño events due to greenhouse warming. Nature Climate Change, 2014





SAPRISE Headline Numbers

- Three major project meetings (Pune, Exeter, Delhi) plus numerous other smaller meetings
- 35+ publications associated with the project
- 5 publications in Nature Climate Change, one in Nature Geosciences
- Key messages
  - Observational errors may soon limit progress in improving climate models
  - Models can capture Monsoon-response to canonical El Niños but not Modoki events
  - Aerosol emissions oppose the global warming signal in Monsoon rainfall, which is projected to increase as emissions reduce

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SAPRISE Synthesis Paper

- To summarize the current state-of-the-art in S. Asian Monsoon prediction and projection

- Focus on key areas
  - Current status of observations
  - Current status of models
  - Remote teleconnections, their mechanisms and their changes through time
  - Effects of aerosols and their interaction with the greenhouse gas signal

- Recommendations for future research

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SAPRISE Publications (Page 1)

1. Ashok, K., Date, S., Swapna, P. and Sabin, T.P. Revisiting El Nino Modokis. In Press Clim. Dyn.
2. Borlace S, Santoso A, Cai W, Collins M. (2014) Extreme swings of the South Pacific Convergence Zone and the different types of El Niño events, Geophysical Research Letters, volume 41, no. 13, pages 4695-4703.
3. Bush, S. J., A. G. Turner, S. J. Woolnough, Gill M. Martin and N. P. Klingaman (2014) The effect of increased convective entrainment on Asian monsoon biases in the MetUM General Circulation Model. Quarterly Journal of the Royal Meteorological Society, published online 24 March 2014. DOI: 10.1002/qj.2371
4. Bush ,S. J., R. C. Levine, A. G. Turner, G. M. Martin, S. J. Woolnough, R. Schiemann, M. S. Mizielinski, M. J. Roberts, P. L. Vidale, M.-E. Demory and J. Strachan. The resolution sensitivity of the South Asian monsoon and Indo-Pacific in a global 0.3° AGCM. Climate Dynamics, submitted 5 September 2014.
5. Cai, W., Borlace, S., Lengaigne, M., van Rensch, P., Collins, M., Vecchi, G., Timmermann, A., Santoso, A., McPhaden, M.J., Wu, L., England, M.H., Wang, G., Guilyardi, E. and Jin, F.-F., 2014. Increasing frequency of extreme El Nino events due to greenhouse warming. Nature Climate Change, 4(2): 111-116**.**
6. Cai, W.J., Zheng, X.T., Weller, E., Collins, M., Cowan, T., Lengaigne, M., Yu, W.D., Yamagata, T., Projected response of the Indian Ocean Dipole to greenhouse warming. Nature Geosciences, vol 6, no 12, 999-1007, 2013.
7. Cai, W., Wang, G., Santoso, A., McPhaden, M.J., Wu, L., Jin, F.-F., Timmermann, A., Collins, M., Vecchi, G., Lengaigne, M., England, M.H., Dommenget, D., Takahshi, K., Guilyardi, E., Increased frequency of extreme La Niña events under greenhouse warming. Nature Climate Change, DOI: 10.1038/NCLIMATE2492
8. Cho, M.-H., K.-O. Boo, G. M. Martin, J. Lee, and G.-H. Lim: The impact of land cover generated by a dynamic vegetation model on climate over East Asia in present and possible future climate. Under discussion at Earth System Dynamics Discuss, http://www.earth-syst-dynam-discuss.net/5/1319/2014/
9. Collins, M., AchutaRao, K., Ashok, K. Bhandari, S., Mitra, A.K., Prakash, S., Srivastava, R.,Turner, A. Observational challenges in evaluating climate models. Nature Climate Change, vol 3, no. 11, 940-941, 2013.
10. Date, S., Ashok, K., Swapna, P., Terray, P. and Revadekar, J.V. (2013) Tropical Indian Ocean SST variability in different CMIP5 scenarios. Submitted to Clim. Dyn.
11. Guo, L., Turner A.G., and E. J. Highwood. Impacts of 20th century aerosol emissions on the South Asian monsoon in the CMIP5 models. Environmental Research Letters, DOI: 10.5194/acpd-14-30639-2014
12. Hunt, Kieran M. R., Andrew G. Turner, Peter M. Inness, David Parker, and Richard C. Levine. On the Paradigm of the Indian Monsoon Depression. Monthly Weather Review, submitted November 2014.

SAPRISE Publications (Page 2)

13. Jourdain, N.C., Sen Gupta, A., Taschetto, A.S., Ummenhofer, C.C., Moise, A.F., Ashok, K. (2013) The Indo-Australian monsoon and its relationship to ENSO and IOD in reanalysis data and in the CMIP3/CMIP5 simulations. Clim. Dyn. published online.
14. Karmacharya, J, RC Levine, R Jones, W Moufouma-Okia, M New (submitted 2014), Sensitivity of systematic biases in South Asian summer monsoon simulations to regional climate model domain size and implications for downscaled regional process studies , submitted to Climate Dynamics
15. Krishnan, R., T. P. Sabin, D. C. Ayantika, A. Kitoh, M. Sugi, H. Murakami, A. G. Turner, J. M. Slingo and K. Rajendran (2013) Will the South Asian monsoon overturning circulation stabilize any further? Clim. Dyn., 40(1), pgs 187-211.
16. Levine, R. C., Turner, A. G., Marathayil, D., and Martin, G. (2012). The role of northern Arabian Sea surface temperature biases in CMIP5 model simulations and future projections of Indian summer monsoon rainfall. Climate Dynamics, accepted.
17. Marathe, S., Ashok, K., P. Swapna, and P. Sabin 2015: Revisiting El Niño Modokis Under revision for Climate Dynamics
18. Marathayil, D., Turner, A. G., Shaffrey, L. C., and Levine, R. C. (2013). Systematic winter SST biases in the northern Arabian Sea in HiGEM and the CMIP3 models. Environmental Research Letters, 8(1), 014028. doi:10.1088/1748-9326/8/1/014028
19. Mehta, V.M., Wang, H. and Mendoza, K. (2013) Decadal predictability of tropical basin average and global average sea surface temperatures in CMIP5 experiments with the HadCM3, GFDL-CM2.1, NCAR-CCSM4, and MIROC5 global Earth System Models. Geophys, Res. Letts., Vol. 40, 1–6, doi:10.1002/grl.50236.
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21. Mitra, A. K., I.M.Momin, E.N.Rajagopal, S.Basu, M.N.Rajeevan and T.N.Krishnamurti, 2013, 'Gridded Daily Indian Monsoon Rainfall for 14 Seasons: Merged TRMM and IMD Gauge Analyzed Values', J. of Earth System Science (Springer), 122(5),1173-1182. [DOI: 10.1007/s12040-013-0338-3]
22. Prakash, S., Mitra, A.K., Momin, I.M., Rajagopal, E.N., Basu, S., Collins, M., Turner, A.G., AchutaRao, K., Ashok, K., Seasonal intercomparison of observational rainfall datasets over India during the south-west monsoon season. International Journal of Climatology, DOI: 10.1002/joc.4129
23. Prakash, S., Mitra, A.K., Momin, I.M., Rajagopal, E.N., Basu, S., Agreement between monthly land rainfall estimates from TRMM-PR and gauge-based observations over the South Asia. Remote Sensing Letters, DOI:10.1080/2150704X.2014.934401.
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25. Prakash, S., Ashis K. Mitra, E. N. Rajagopal and D. S. Pai, Jan 2015, 'Assessment of TRMM-based TMPA-3B42 and GSMaP precipitation products over India for the peak southwest monsoon season', Intl. J. of Climatology (RMS), Under review.

SAPRISE Publications (Page 3)

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27. Prakash, S., C. Mahesh, V. Sathiyamoorthy, R. M. Gairola & A. K. Mitra. 2014. An investigation of long-term changes in rainfall over the equatorial Indian Ocean trough region during northern summer using multisatellite data. Theor Appl Climatol DOI 10.1007/s00704-015-1406-1.
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Thank You