Performance of the GFS Model: land v/s Ocean

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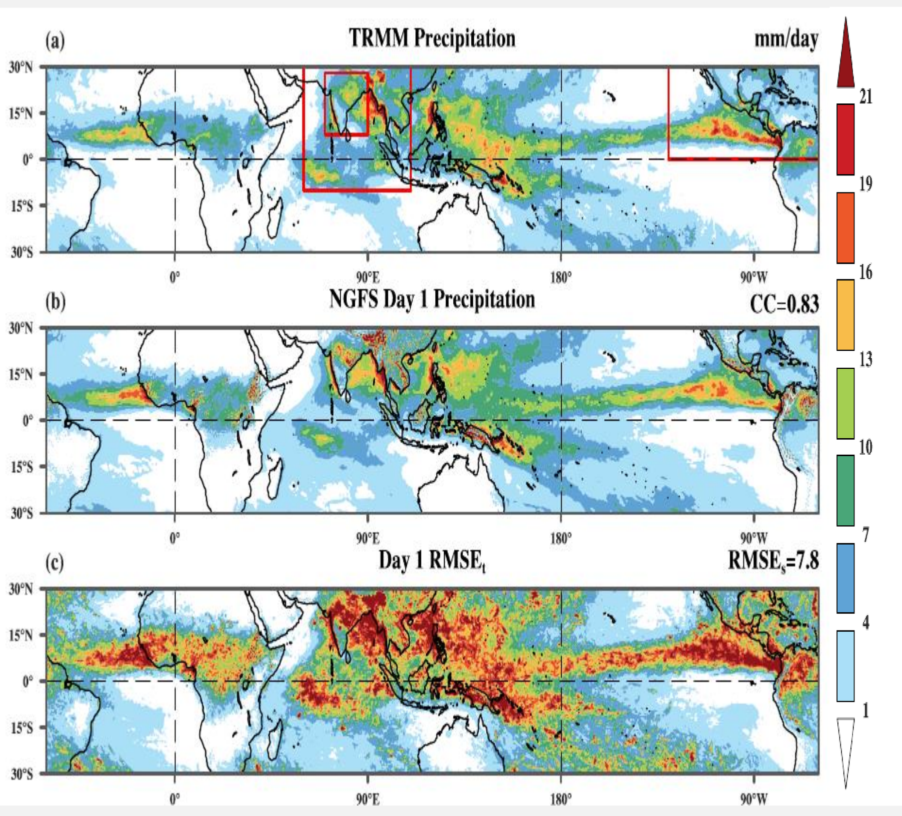
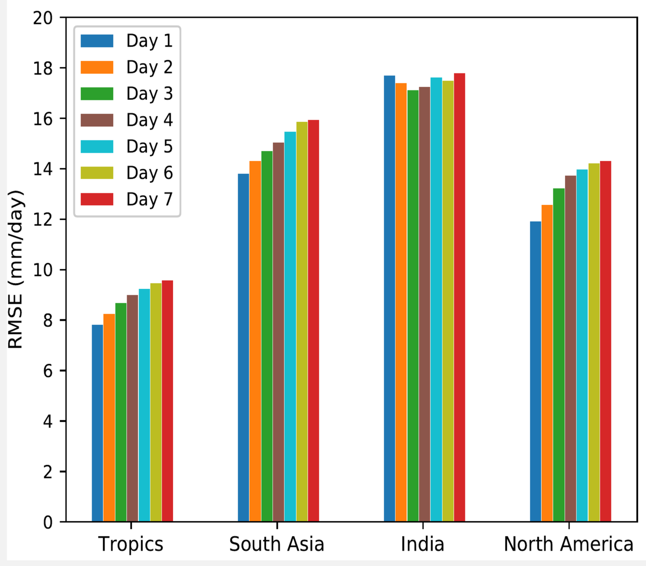
1. Objective:

To characterize the error in precipitation forecast, of the high-resolution Global Forecast System (GFS).

Domain: South-Asia. **Year**: June-September, 2012 **Observation**: 6-hourly precipitation, TRMM 3B42

2. Seasonal mean precipitation & error growth:

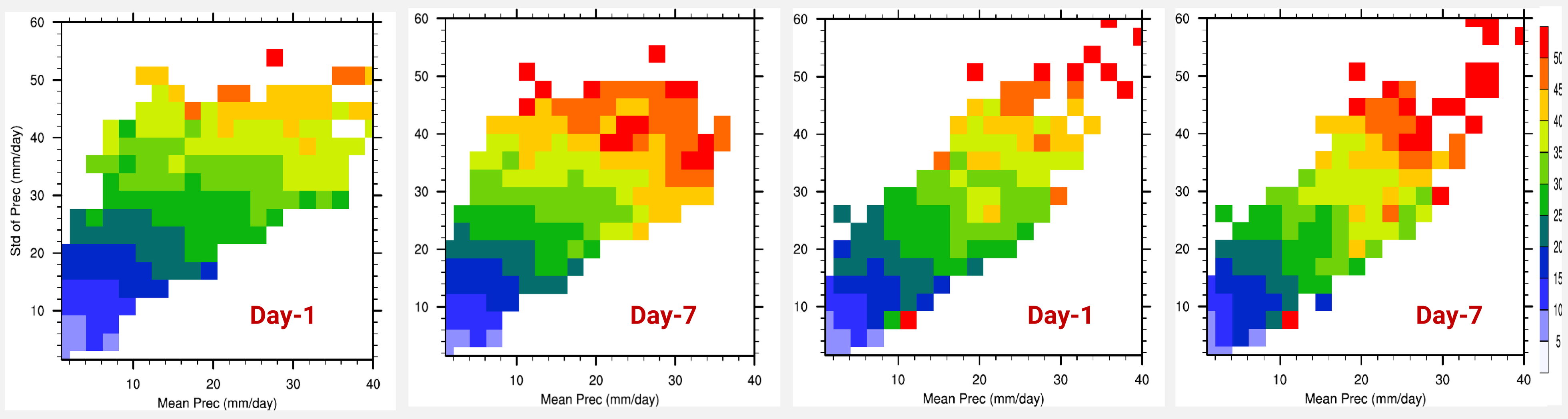




- **Maximum error**: Indian region
- **Highest growth rate**: South Asian region

3. Error pattern with lead time:

Ocean **Land**



Error increases with lead time over grids with low mean precipitation and high std.

With lead time, error is higher over grids having high precipitation and std.

4. Error and its component analysis:

Decomposition of Mean square error (MSE) (*Yang (2017)*[1])

$$E^2 = \underbrace{(\bar{M}-\bar{O})^2}_{\text{Error by mean difference}} + \underbrace{(\sigma_M{}^2 + \sigma_O{}^2 - 2\sigma_M\sigma_O R)}_{\text{Error by phase variation}}$$

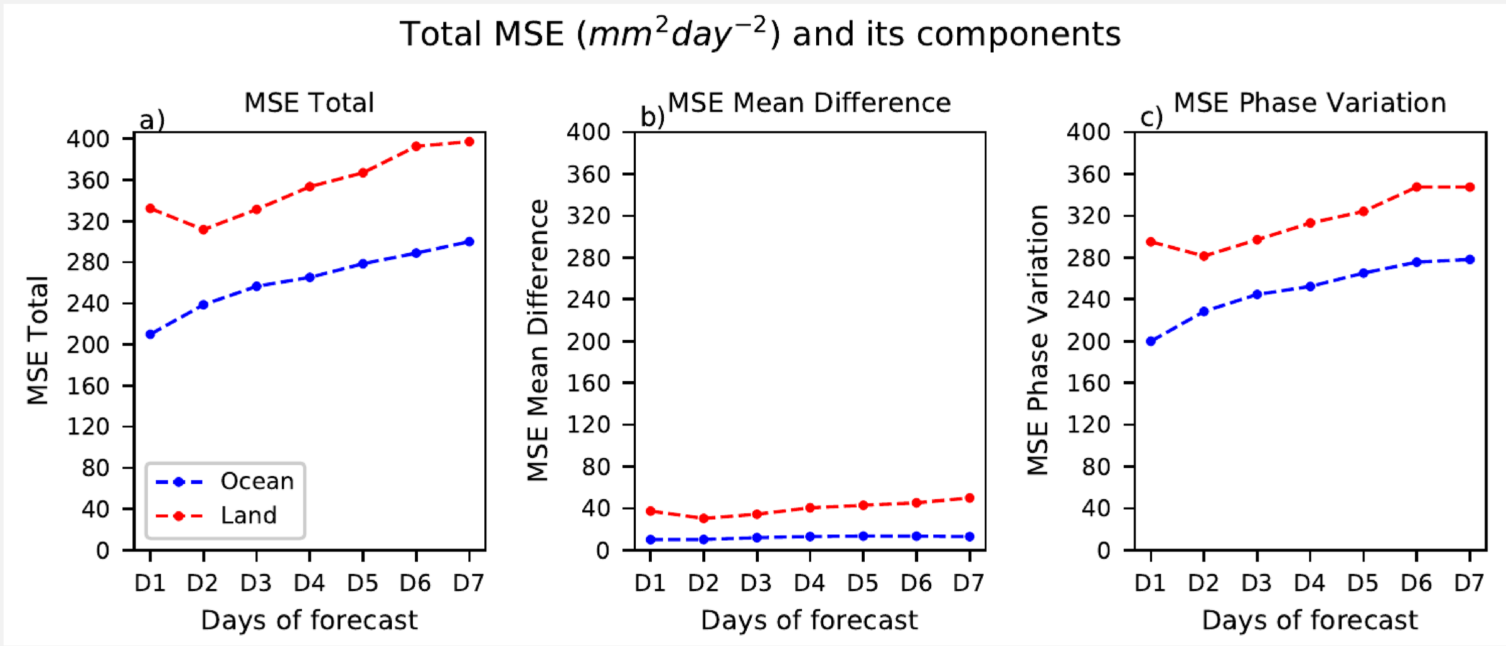
Variance of forecast analysis:

$$\sigma_M{}^2 = \frac{1}{N}\Sigma_{i=1}^{N}[(M_i - \bar{M})^2]$$

$$\sigma_O{}^2 = \frac{1}{N}\Sigma_{i=1}^{N}[(O_i - \bar{O})^2]$$

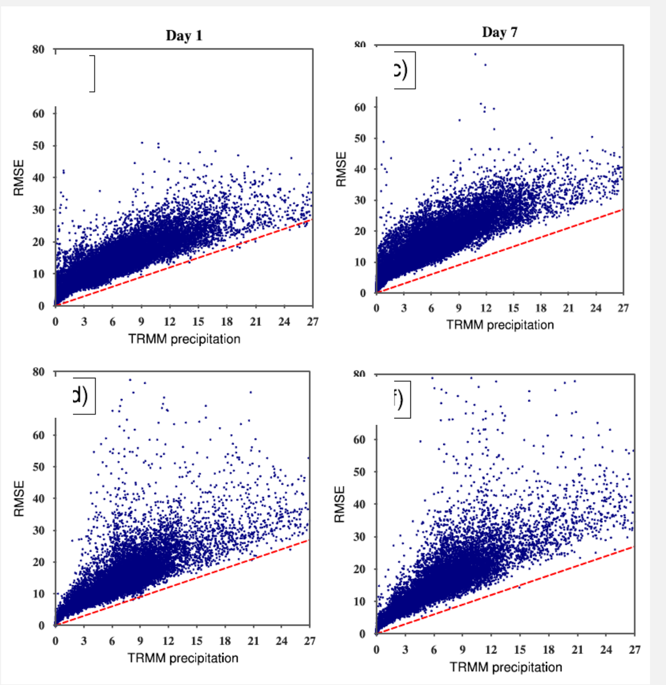
Anomalous phase correlation:

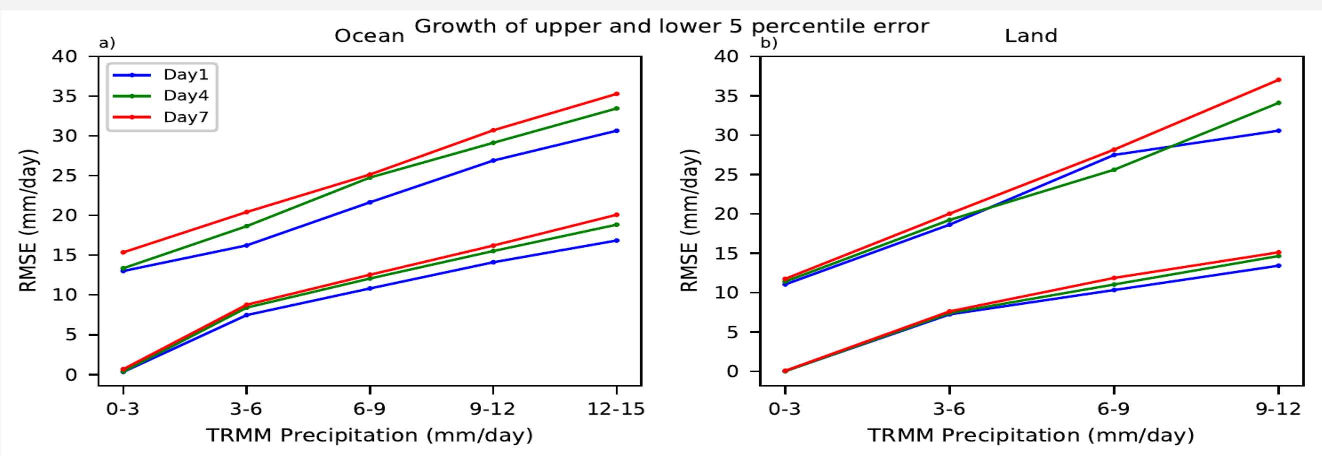
$$R = [\frac{1}{N}\Sigma_{i=1}^{N}[\frac{(M_i-\bar{M})-(O_i-\bar{O})}{\sigma_M\sigma_O}]]$$



- Phase variation contributes to more than 90% of the MSE. This arises from the inadequacy of model to capture daily and diurnal variations.
- For all lead time, the intensity of error is higher over land as compared to the ocean but growth rate is similar.

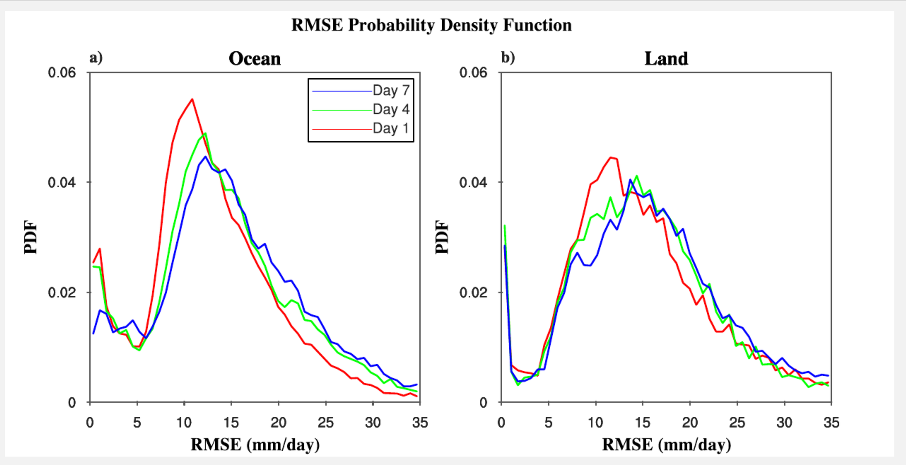
5. Error growth characteristics with lead time:





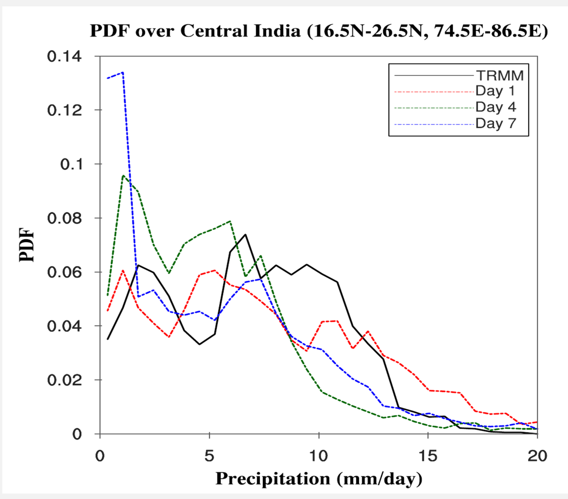
Ocean:
- Error growth of upper-5 %tile is higher than lower-5 %tile, because of an increase in the number of grids having high error.

Land:
- Increase in upper-5 %tile error is limited especially for lower range of precipitation.



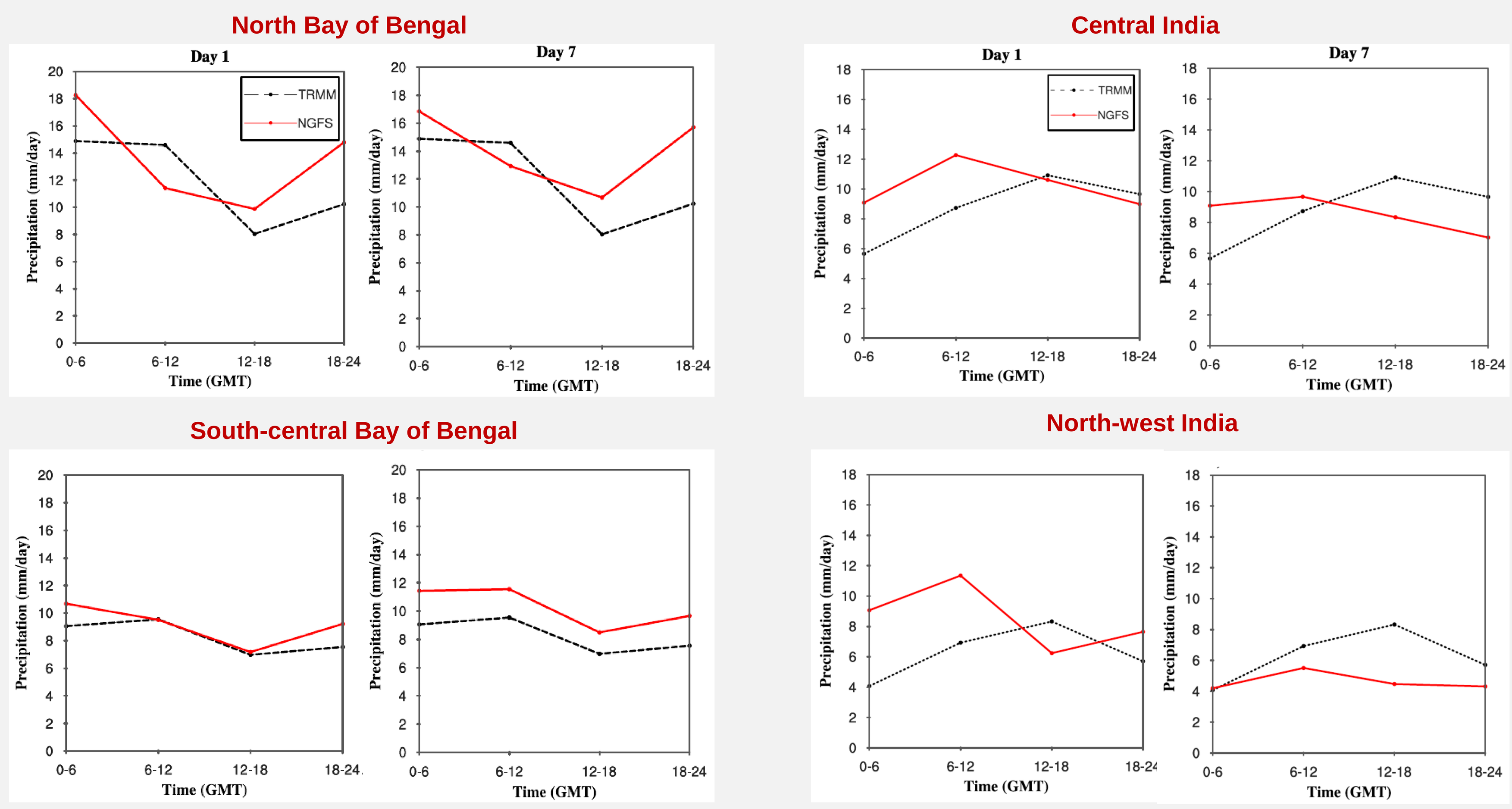
- For a smaller of RMSE, there is not much change in the number of grids over both land and ocean.
- For higher, upward shift in pdf over ocean only.

6. Intra-seasonal Variation:



- Observation shows bimodal distribuition of rainfall.
- With lead time, model forecast progresses towards the weak spells, i.e., a large number of grids having very low rainfall.

7. Diurnal cycle:



Ocean: Systematic bias **Land:** 6-hour phase error

8. Conclusions:

- Model behaviour is different over land and ocean.
- Large MSE over both land and ocean is due to inability of the model to capture the correct **phase** of precipitation.
- Large error over ocean is due to increase in grids having high error. However, such increase is **limited** over land.
- With lead time, model overpredicts the **break phase** in intra-seasonal timescale.
- Diurnal cycle shows **systematic** bias over ocean and **6-hour phase** error over land.

References

[1] Yang F (2017) Decomposition and attribution of forecast errors. 7 International Verification Methods Workshop Berlin, Germany