# Predictability of tropical rainfall in the ECMWF seasonal forecast systems

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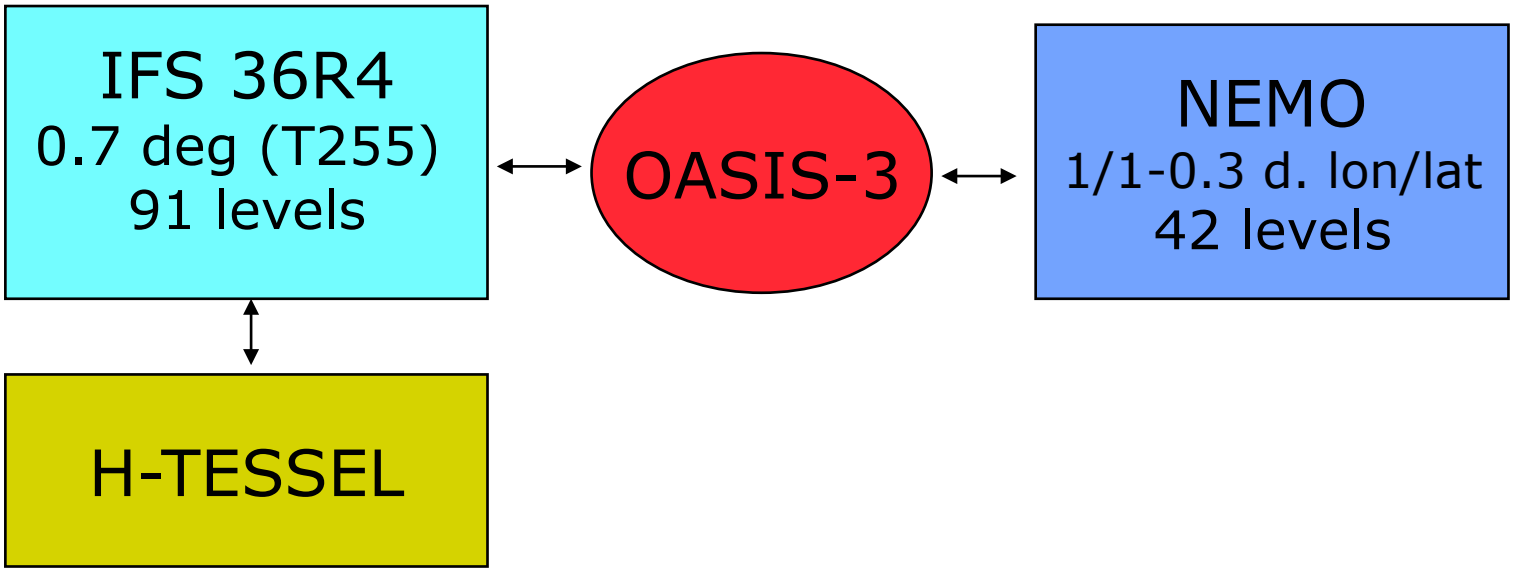
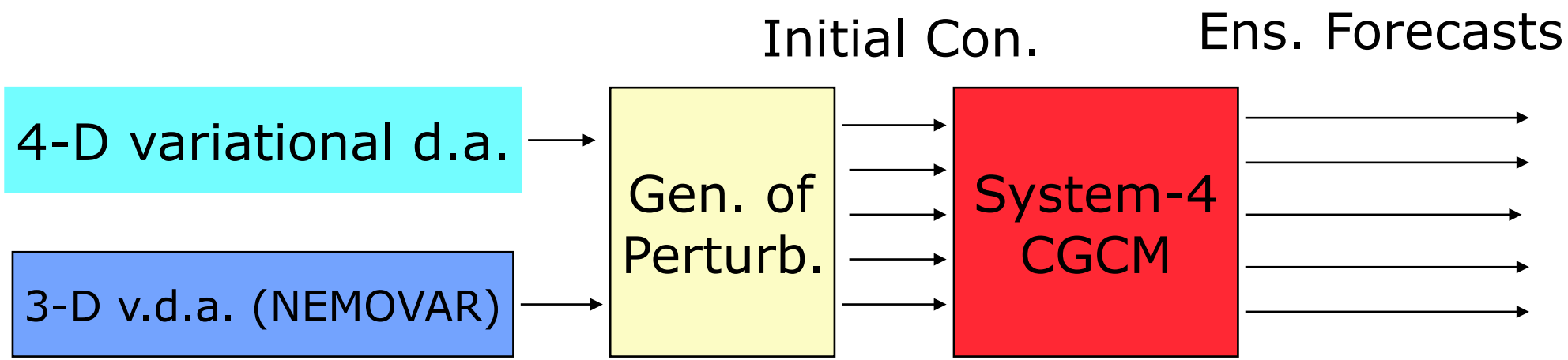
# The new ECMWF Seasonal fc. system (Sys-4)



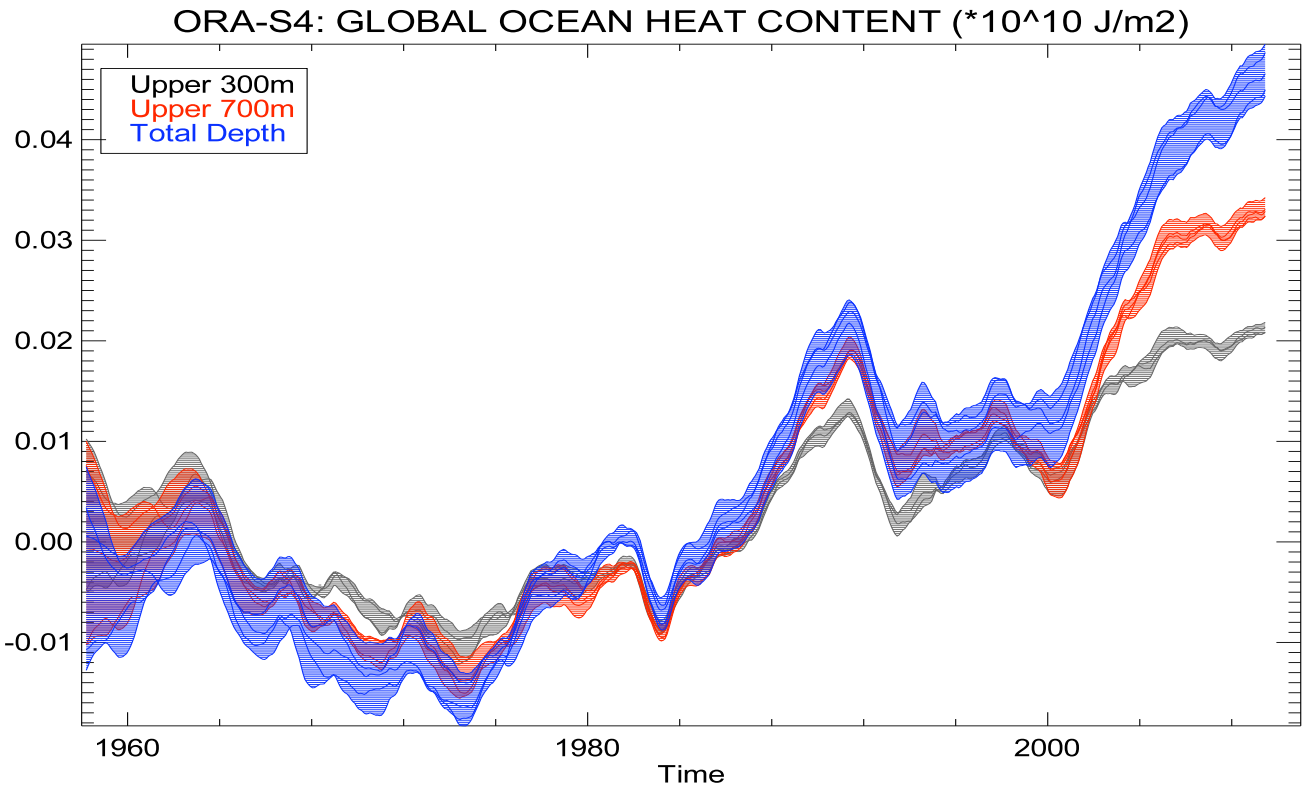
# ECMWF System 4: main features

- **Operational forecasts**
  - 51-member ensemble from 1st day of the month
  - released on the 8th
  - 7-month integration
- **Experimental ENSO outlook**
  - 13-month extension from 1st Feb/May/Aug/Nov
  - 15-member ensemble
- **Re-forecast set**
  - 30 years, start dates from 1 Jan 1981 to 1 Dec 2010
  - 15-member ensembles, 7-month integrations
  - 13-month extension from 1st Feb/May/Aug/Nov

# Decadal variability in ocean heat content from ORA-S4

## Variational ocean data assimilation (NEMOVAR)

- **3-D var FGAT with inner and outer loop**
- **Collaboration with CERFACS, UK Met Office, INRIA**
- **Re-analysis (ORA-S4) and real-time system**



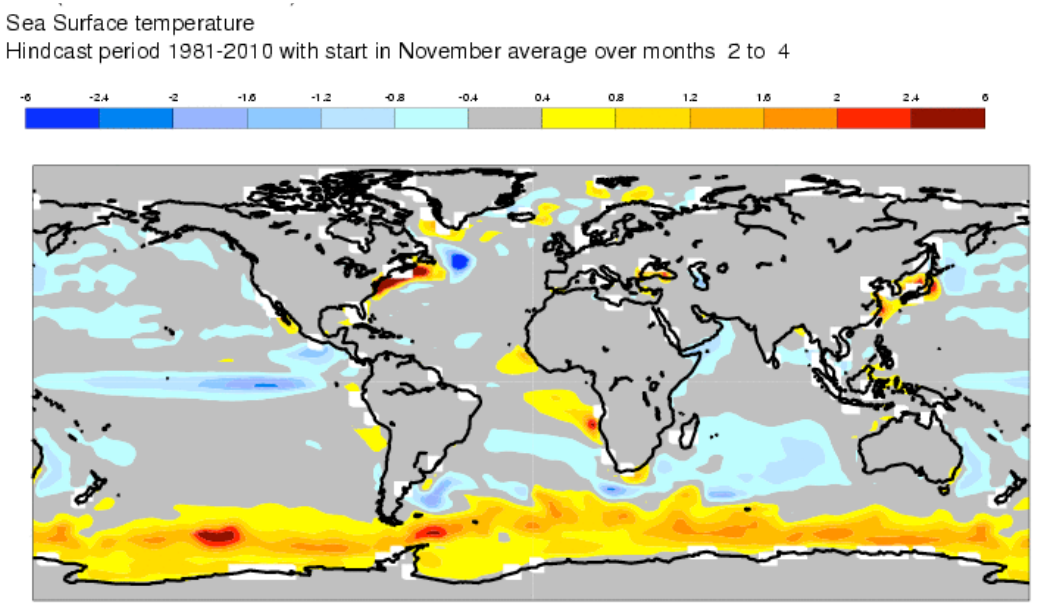
# Bias in S4 re-forecasts: SST (DJF)

Start: 1 Nov.

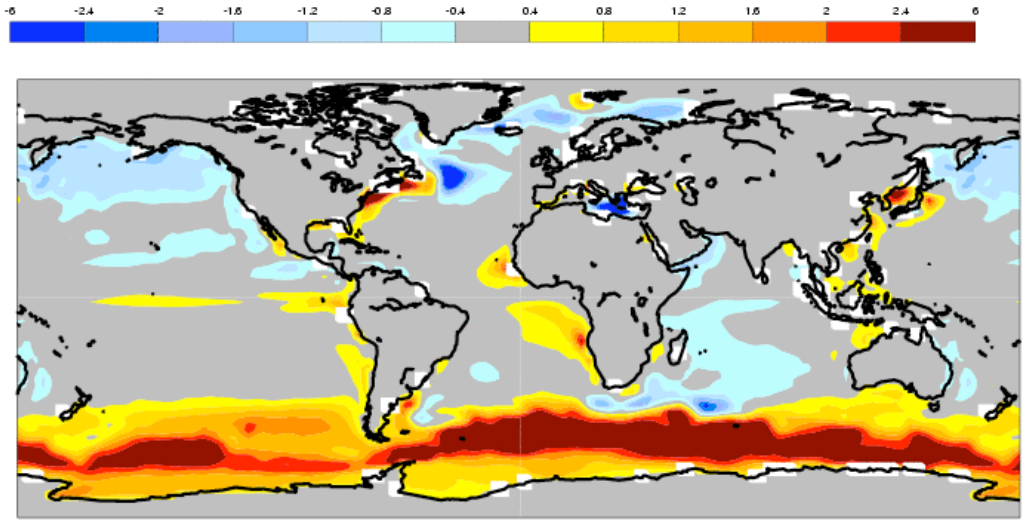
1981/2010

Verify: Dec-Feb

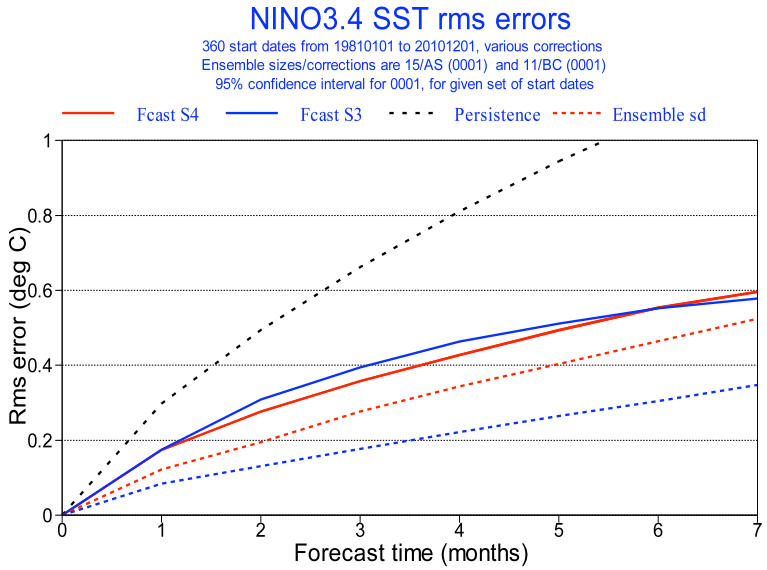
**System 4**



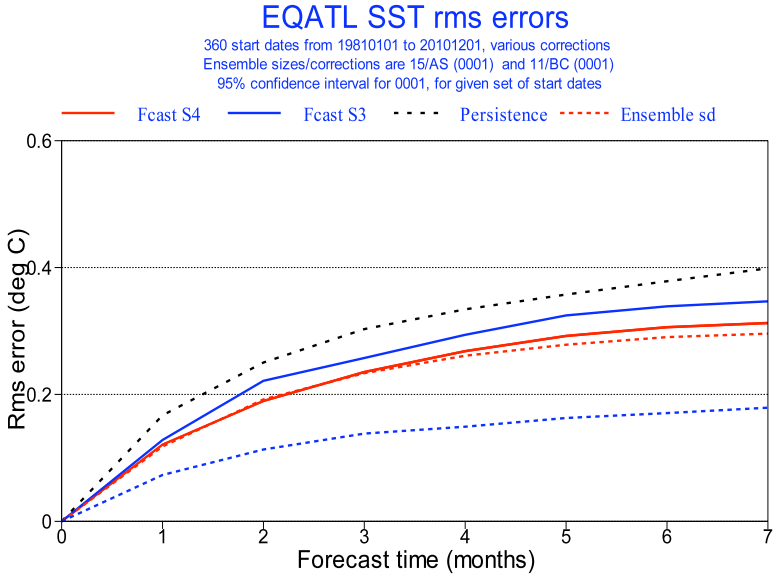

**System 3**

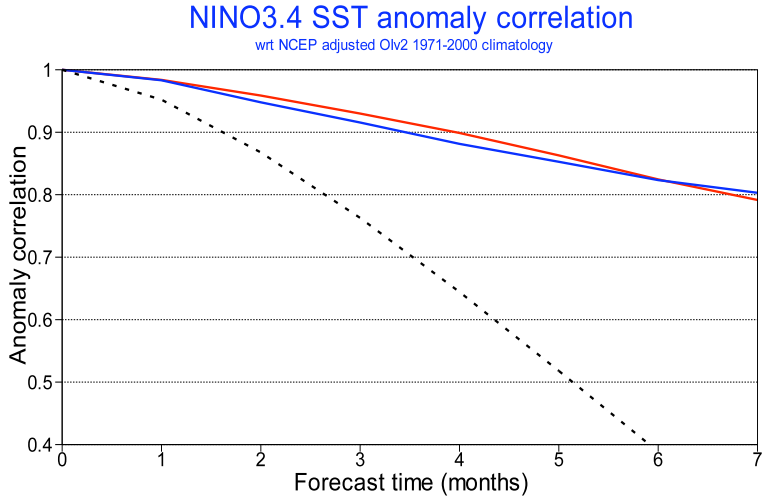


# SST scores: Nino 3.4 and Eq. Atlantic

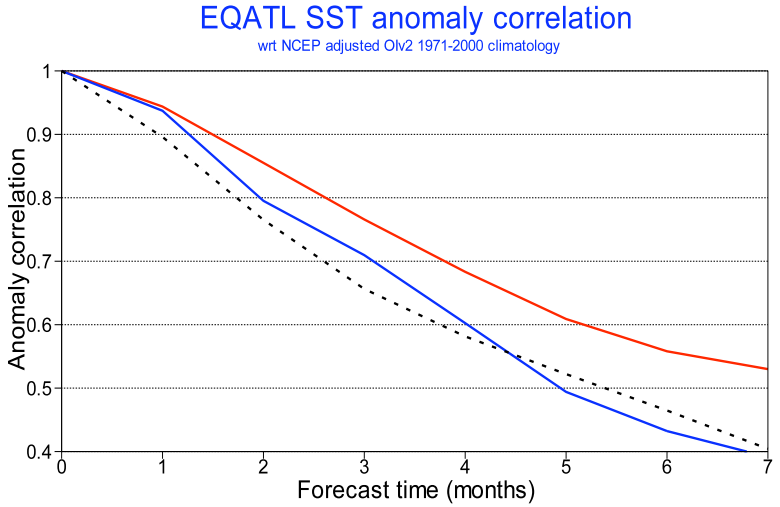



**Solid:**
**S4 error**
**S3 error**
**Dashed:**
**S4 spread**
**S3 spread**




**S4 ACC**
**S3 ACC**
**Pers. ACC**



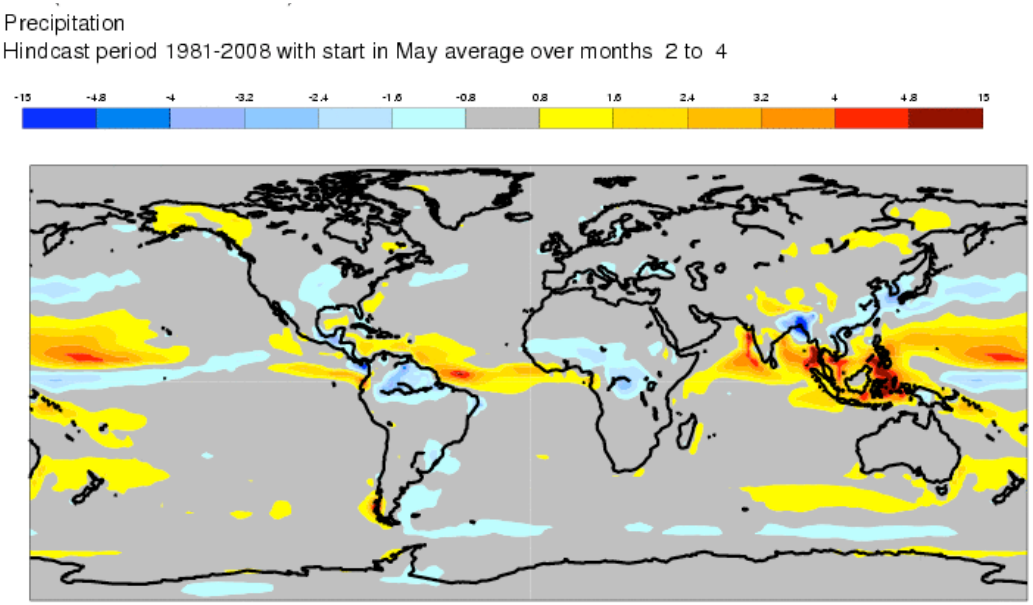
# Bias in S4 re-forecasts: rainfall (JJA)

Start: 1 May

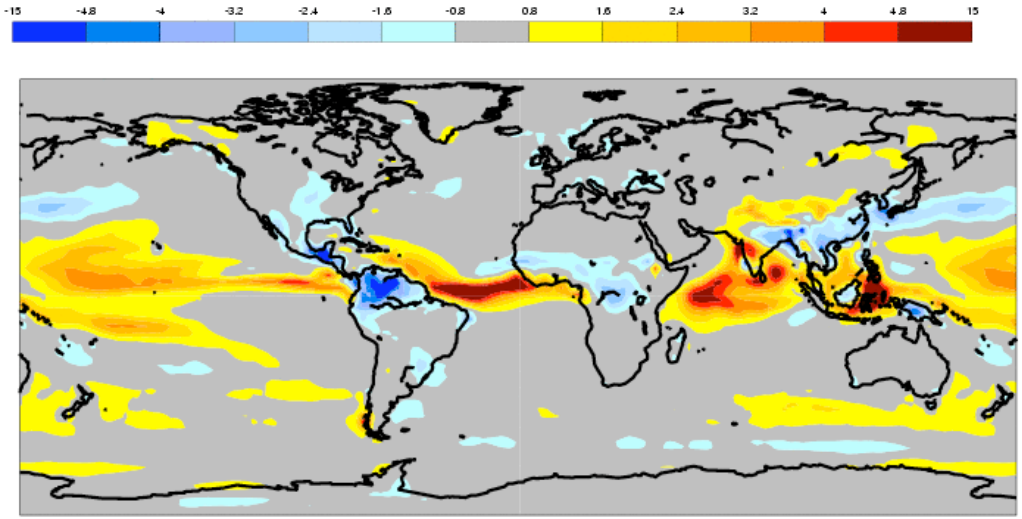
1981/2010

Verify: Jun-Aug

**System 4**




**System 3**



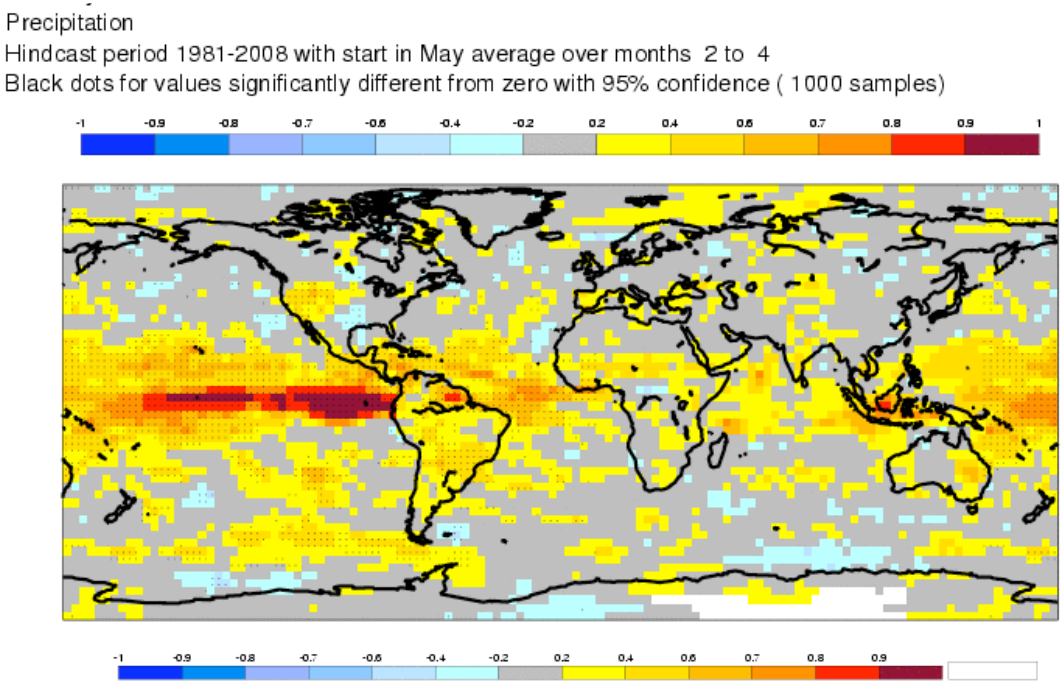
# Ens-mean ACC in S4 re-forecasts: rainfall (JJA)

Start: 1 May

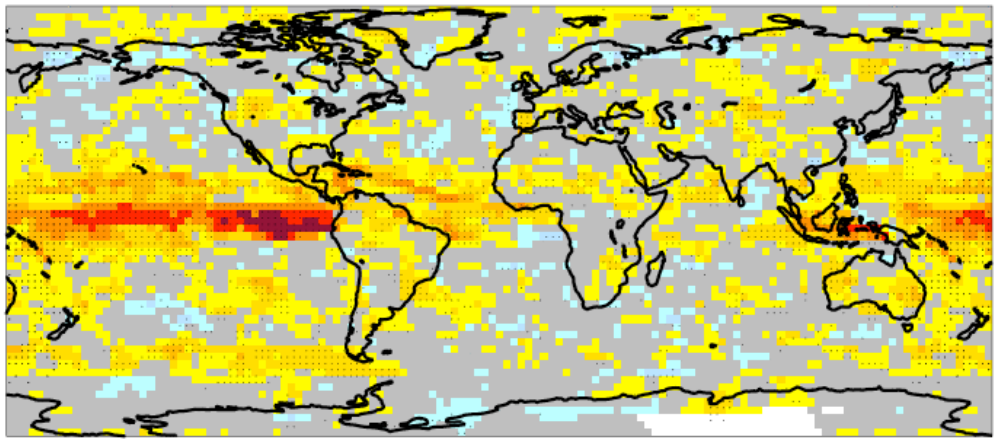
1981/2010

Verify: Jun-Aug

**System 4**




**System 3**



# Validation of leading rainfall EOF/PC in 8 regions

- Comparison of model EOF patterns vs. 1st EOF of GPCP 2.1
- Prediction of the interannual variability of PC1 using 1-to-3-dim. model EOF subspaces
- Comparison of actual vs. perfect-model correlation skill for PC1

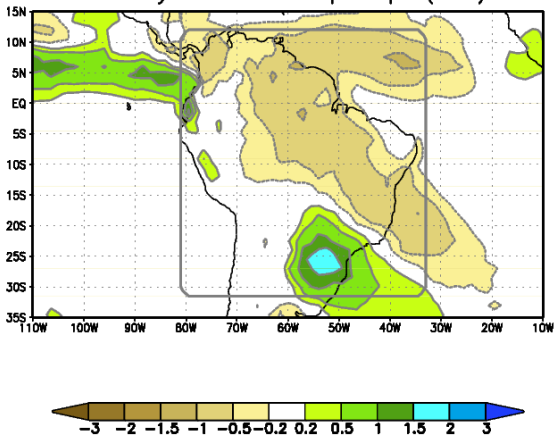
| Region | Acronym | Spatial domain | Seasonal domain |
|---|---|---|---|
| **Central and North America** | CNAM | 130-55W, 10-55N | Jun-Jul-Aug |
| **Tropical South America** | TSAM | 80-35W, 30S-10N | Sep-Oct-Nov |
| **West Africa** | WAF | 20W-25E, 0-25N | Jun-Jul-Aug |
| **Central and Southern Africa** | CSAF | 10-42E, 35S-5N | Dec-Jan-Feb |
| **Europe** | EUR | 15W-45E, 30-75N | Jun-Jul-Aug |
| **South and SouthEast Asia** | SEAS | 60-110E, 5-30N | Jun-Jul-Aug |
| **East Asia** | EAS | 100-160W, 10-55N | Jun-Jul-Aug |
| **Maritime Continents** | MCON | 95-155E, 20S-10N | Dec-Jan-Feb |

# Space and time correlations for rainfall EOF1/PC1

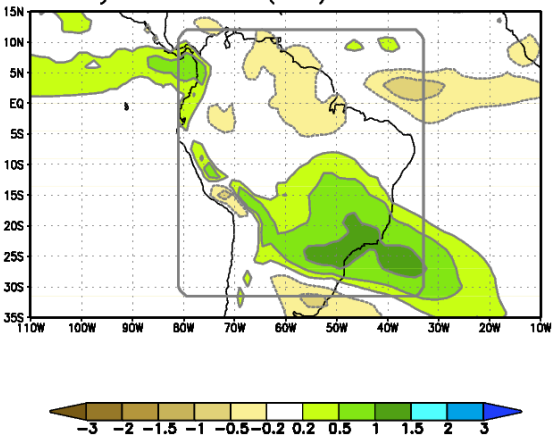
| Region | EOF-1 | | | PC-1 | |
|---|---|---|---|---|---|
| | **S3** | **S4** | | **S3** | **S4** |
| Central and North America | 88 | 85 | | 74 | 74 |
| Tropical South America | 26 | **67** | | 73 *(2)* | 69 *(2)* |
| West Africa | 33 | **71** | | 54 *(3)* | **61** *(3)* |
| Central and South Africa | 69 | **80** | | 69 | 70 |
| Europe | 84 | **92** | | 19 | 17 |
| South and SouthEast Asia | **57** | 5 | | 31 *(2)* | **58** |
| East Asia | 81 | 85 | | **68** | 52 |
| Maritime Continents | 85 | 87 | | 85 | 87 |

# Variability of tropical rainfall: EOF comparison

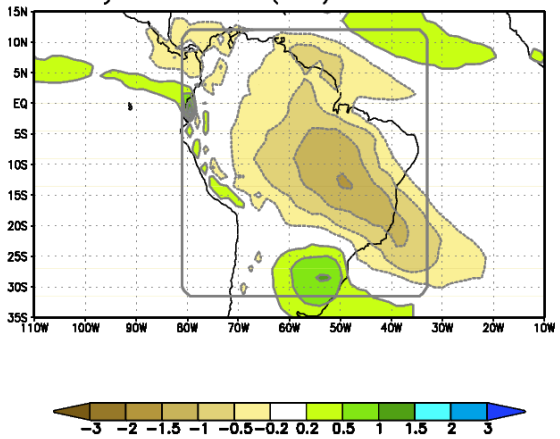
era28y EOF−1 of precip. (son)



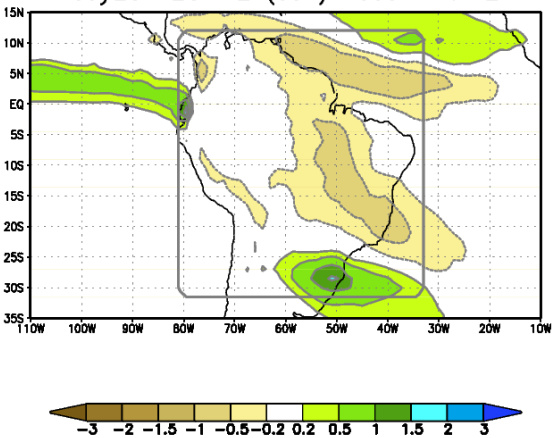

s3y28 EOF−1 (son) acc = 0.26



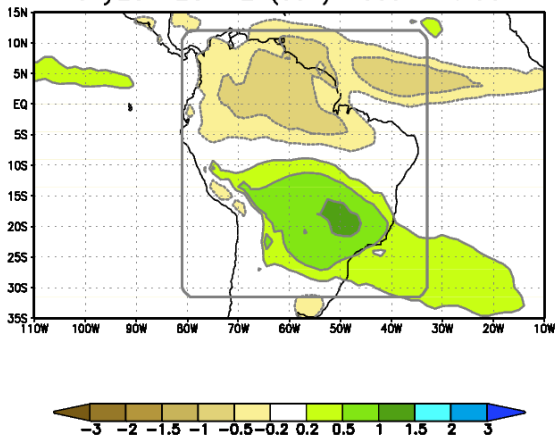

s4y28 EOF−1 (son) acc = 0.67



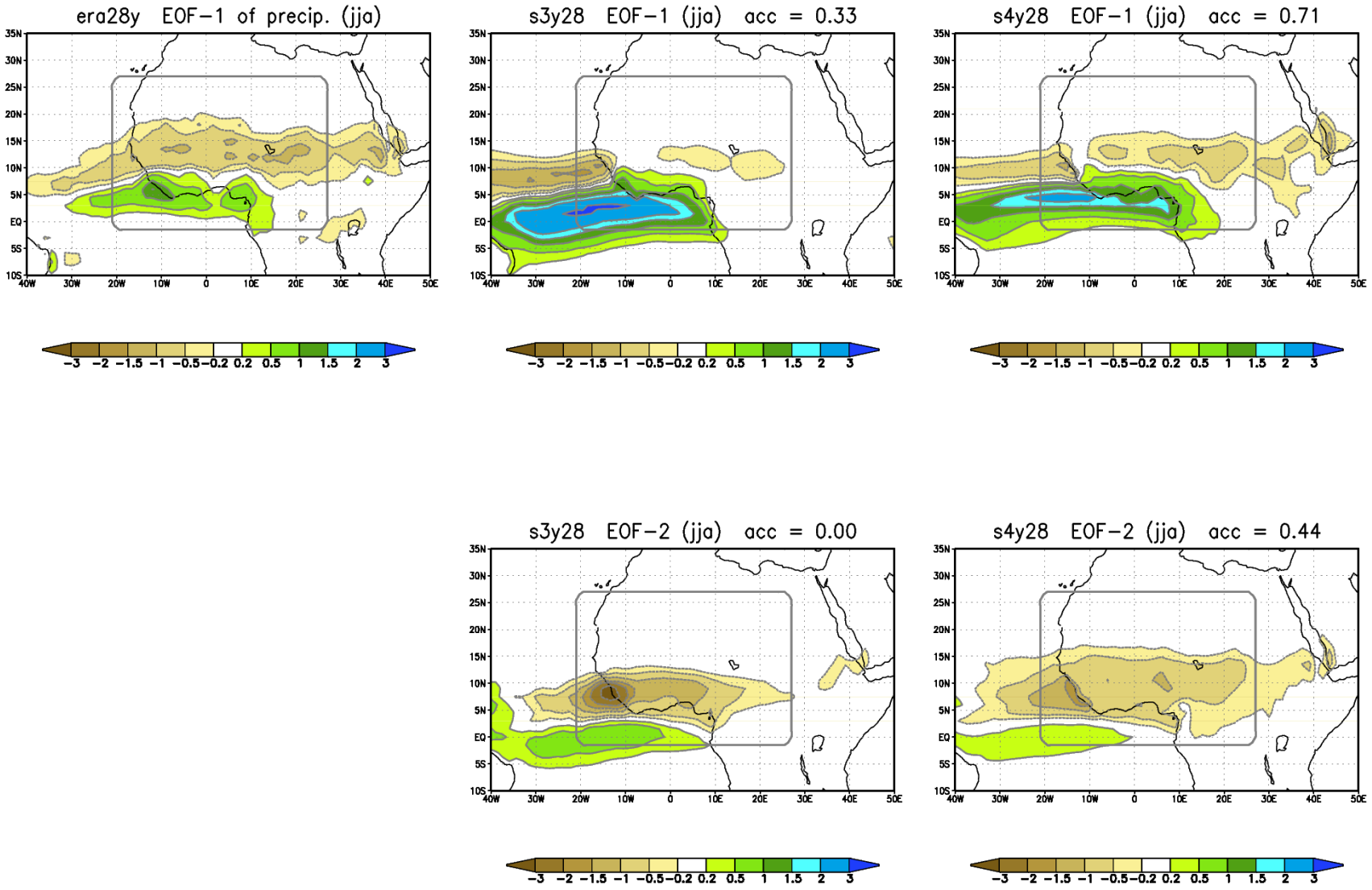

s3y28 EOF−2 (son) acc = 0.72




s4y28 EOF−2 (son) acc = 0.53

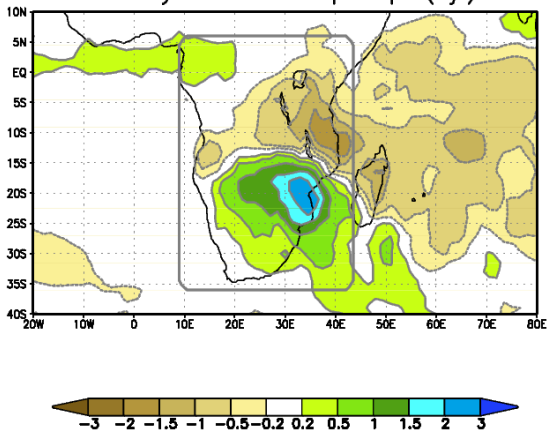


# Variability of tropical rainfall: EOF comparison

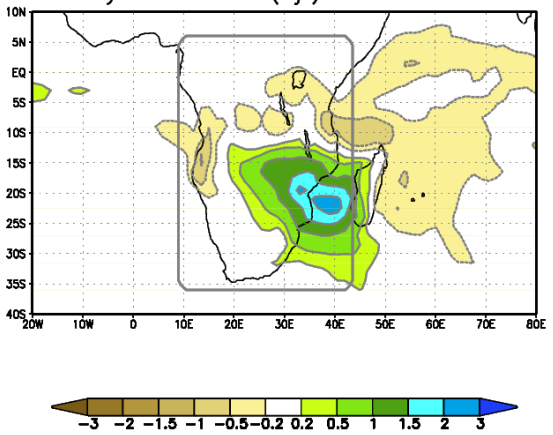


# Variability of tropical rainfall: EOF comparison

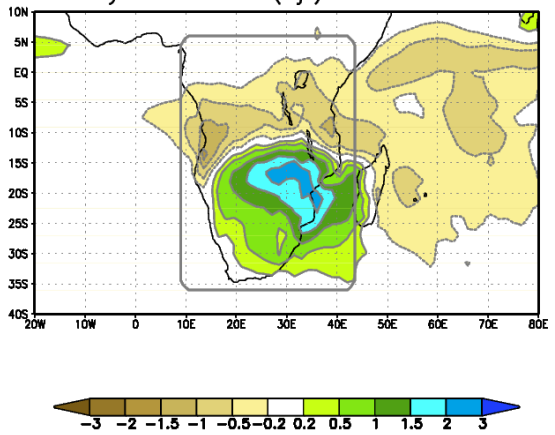
era28y EOF−1 of precip. (djf)



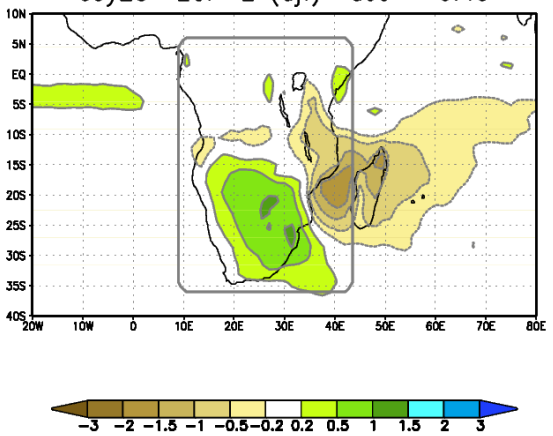

s3y28 EOF−1 (djf) acc = 0.69



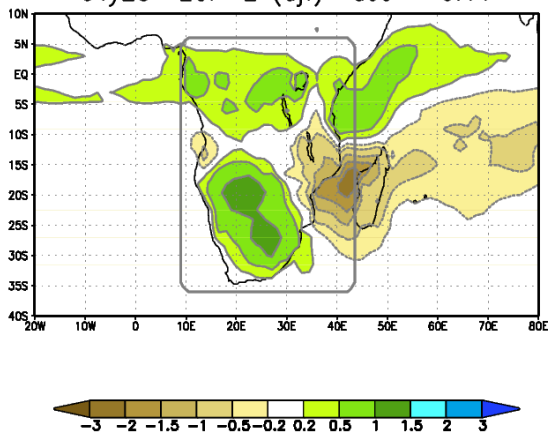

s4y28 EOF−1 (djf) acc = 0.80



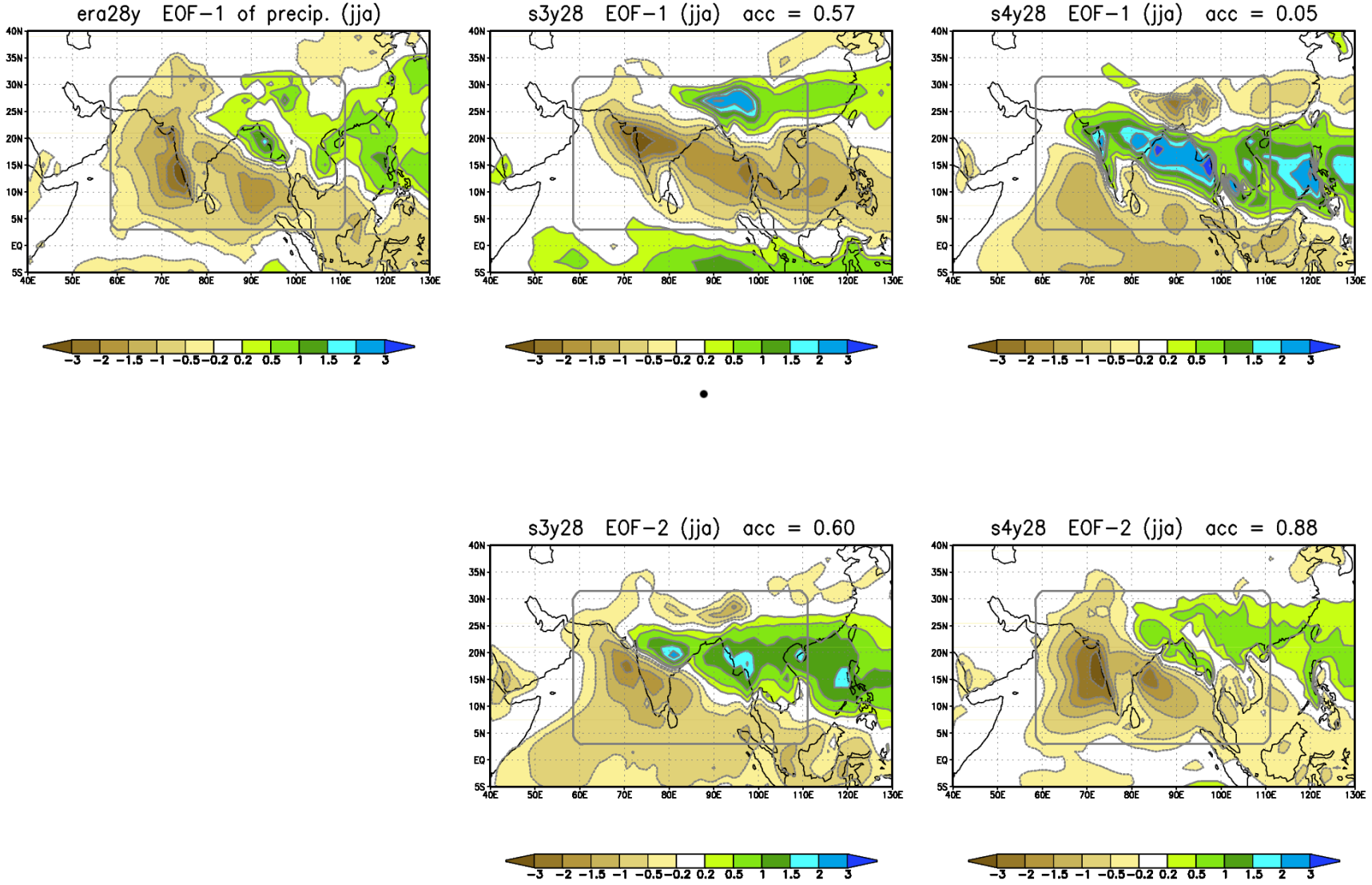

s3y28 EOF−2 (djf) acc = 0.43



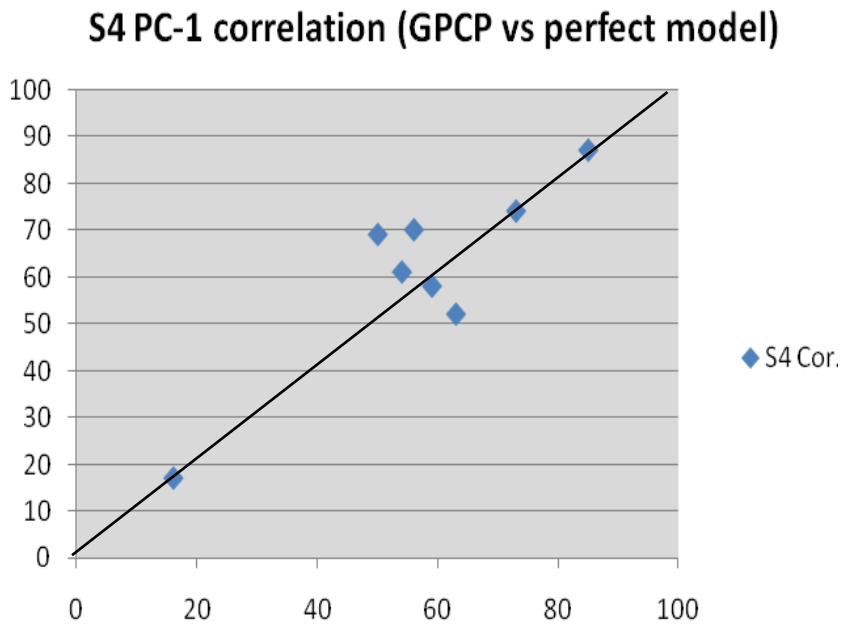

s4y28 EOF−2 (djf) acc = 0.11

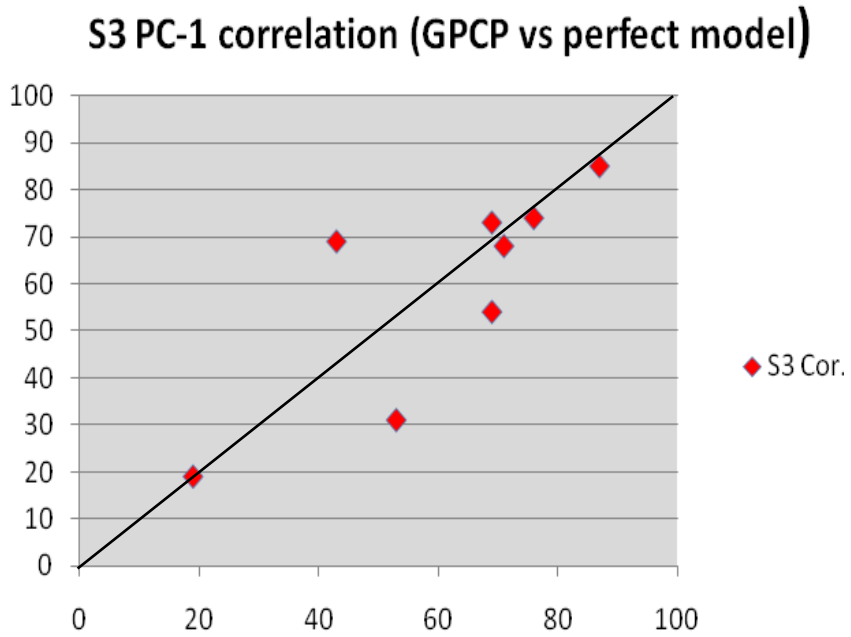


# Variability of tropical rainfall: EOF comparison



# Actual vs. perfect-model skill: rainfall PC-1



# Summary

- **New ECMWF seasonal fc. System-4 (S4):** IFS-NEMO coupled model, 3-D var. ocean data assimilation (NEMOVAR), higher atmos. spatial resolution than S3, larger ensemble size, extended re-forecast set.
- **Rainfall biases in S4**: reduced rainfall biases overall, but with persistent positive bias over the Maritime Continents; consistent with too strong Walker circulation in the West Pacific and related SST biases.
- **Rainfall forecast skill**: S4 similar to S3 in the tropical Pacific, improved over the tropical Atlantic and Indian Oceans, still noisy and often marginal over the continents *when grid-point data are considered.*
- **Leading EOFs of rainfall variability:** more realistic patterns of rainfall variability in S4, especially over South America and Africa. Incorrect teleconnection between West Pacific and the Indian subcontinent. Prediction of GPCP PC1 exceeds 50% correlation over all tropical regions.
- **Reliability:** the enhanced internal variability and better match between spread and error lead to more reliable seasonal forecasts w.r.t. S3 in both tropical and extra-tropical regions.