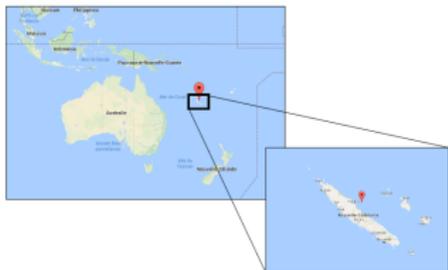# Benefits of a multimodel approach for forecasting precipitation over New Caledonia (SW Pacific) at S2S timescales

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CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France

April 4th, 2019

Fig. 1 : Daily mean rainfall (mm/day) averaged over 28 rain gauge stations in New Caledonia for each MJO phase

- Precipitation in New Caledonia : heavy rainfall and droughts
- Sources of subseasonal predictability in the SW tropical Pacific
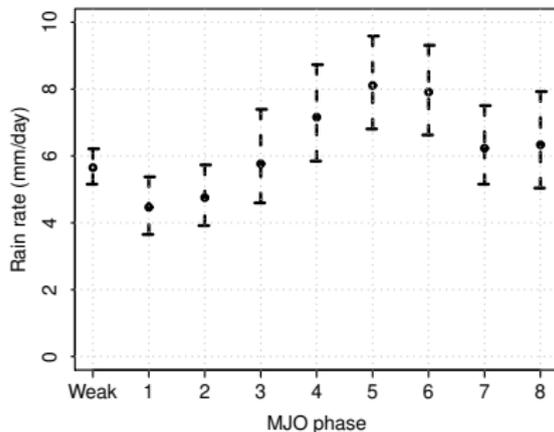- Is it possible to obtain useful information from S2S forecasts for such a small territory ?

# S2S reforecasts and verification

## S2S reforecasts

- 6 models : BoM, CMA, ECCC, ECMWF, Météo-France, UKMO
- Common reforecast period : 1996-2013 (18 years), December-January-February (austral summer) season
- 4 start dates per month (Total : $4 \times 3 \times 18 = 216$ start dates)
- Leads : from week 1 (days 5 to 11) to week 4 (days 26 to 32)

## Probabilistic verification

- Verification dataset : MSWEP v1.2 $0.25°$ precipitation dataset (Beck et al, 2017)
- Event : Weekly precipitation in the upper 20% of 1996-2013 cross-validated climatology
- Probabilities computed by counting the fraction of members where the event occurs
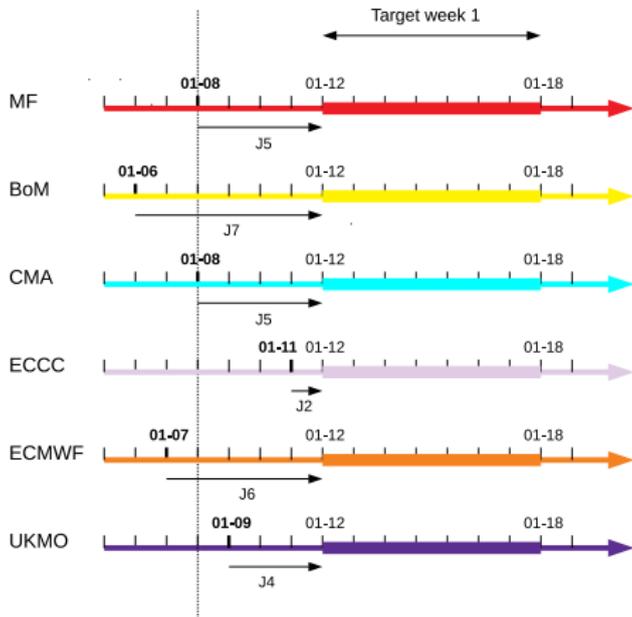- ROC skill score and reliability

# Multimodel ensemble construction



Fig. 2 : Example of multimodel reforecast construction for January 8 start date and target week 1

**Methodology**

- Fixed target week according to the MF calendar
- Correspondence between closest start dates
- Same number of members (1,2,3 or 4) from each model
- Computation of the MME scores for 1,000 random draws
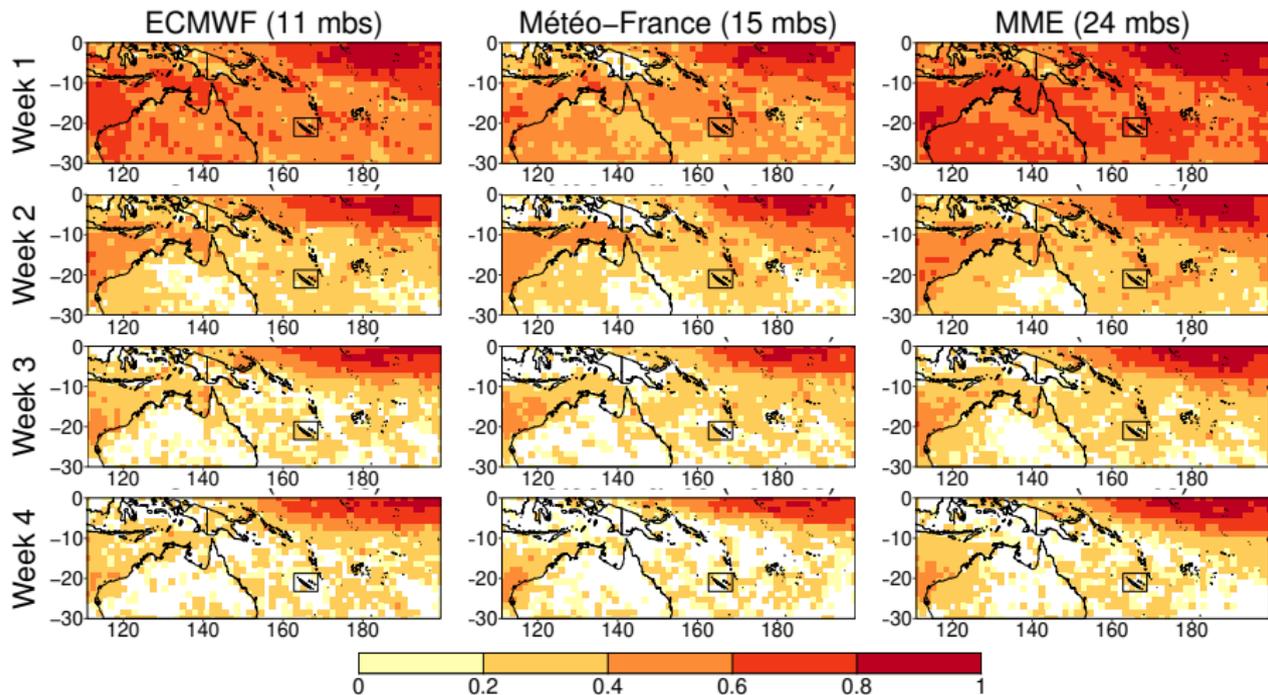- Median of the 1,000 scores and 90% confidence interval

Fig. 3 : ROC skill score for the prediction of the upper 20% of weekly precipitation in S2S reforecasts

# A fair comparison between the MME and single models
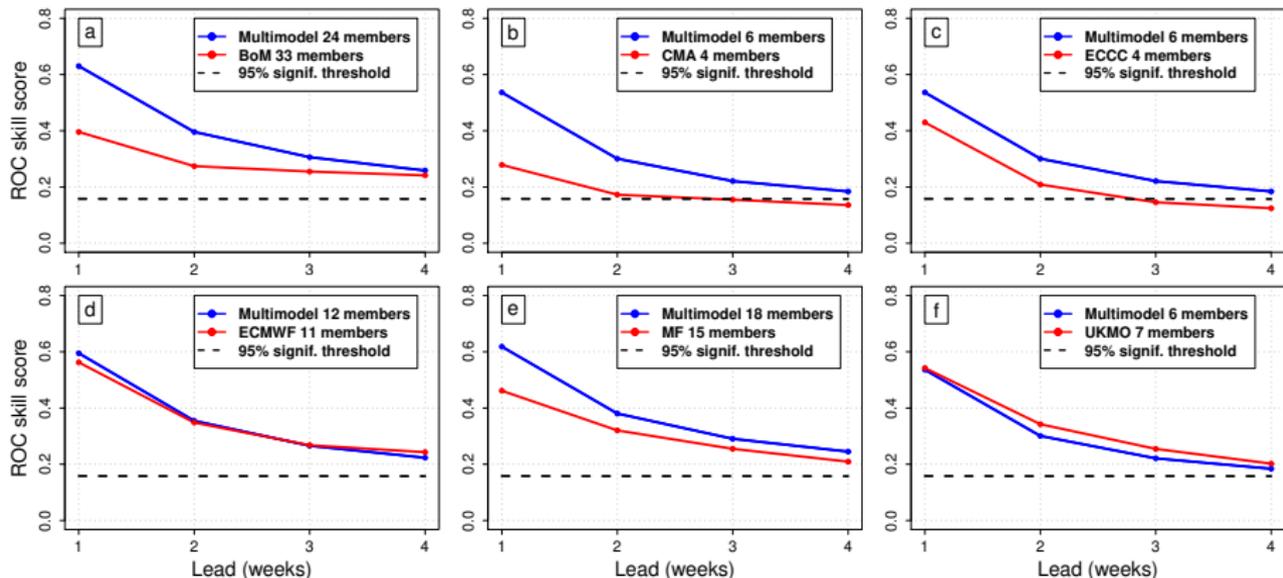
Average score over the SW tropical Pacific domain

Fig. 4 : Comparison between multimodel and single model at an equivalent ensemble size, for the spatial mean of the ROC skill score over the southwest tropical Pacific

# A fair comparison between the MME and single models
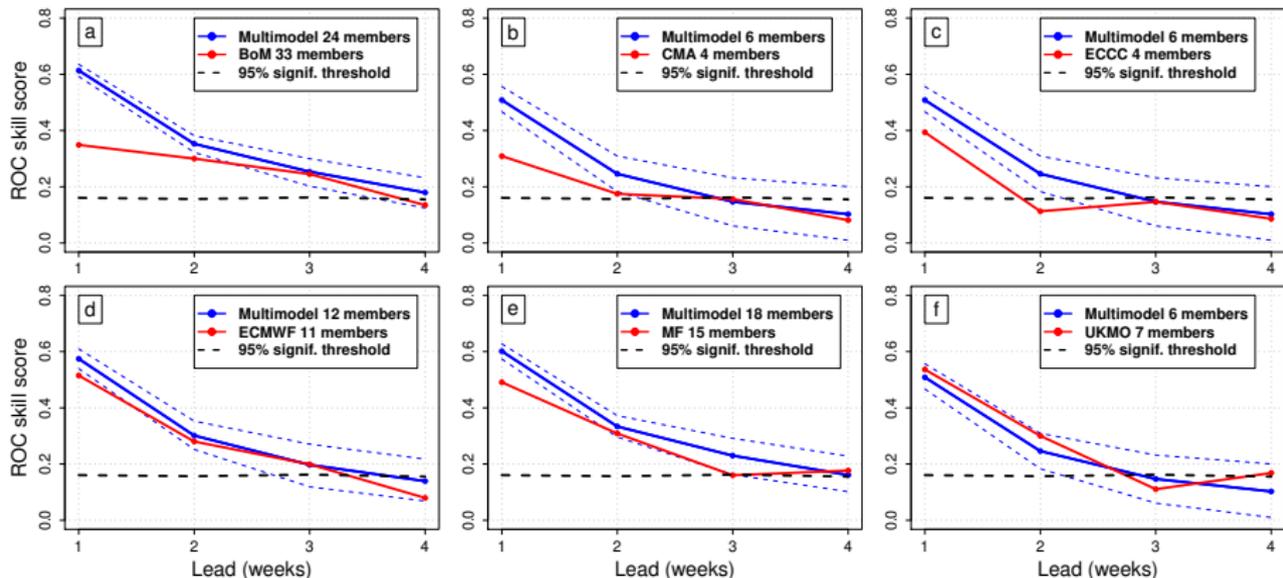
Zoom on New Caledonia (163°E-169°E ; 23°S-19°S)



Fig. 5 : Comparison between multimodel and single model at equivalent ensemble size, for the spatial mean of the ROC skill score over the New Caledonia domain
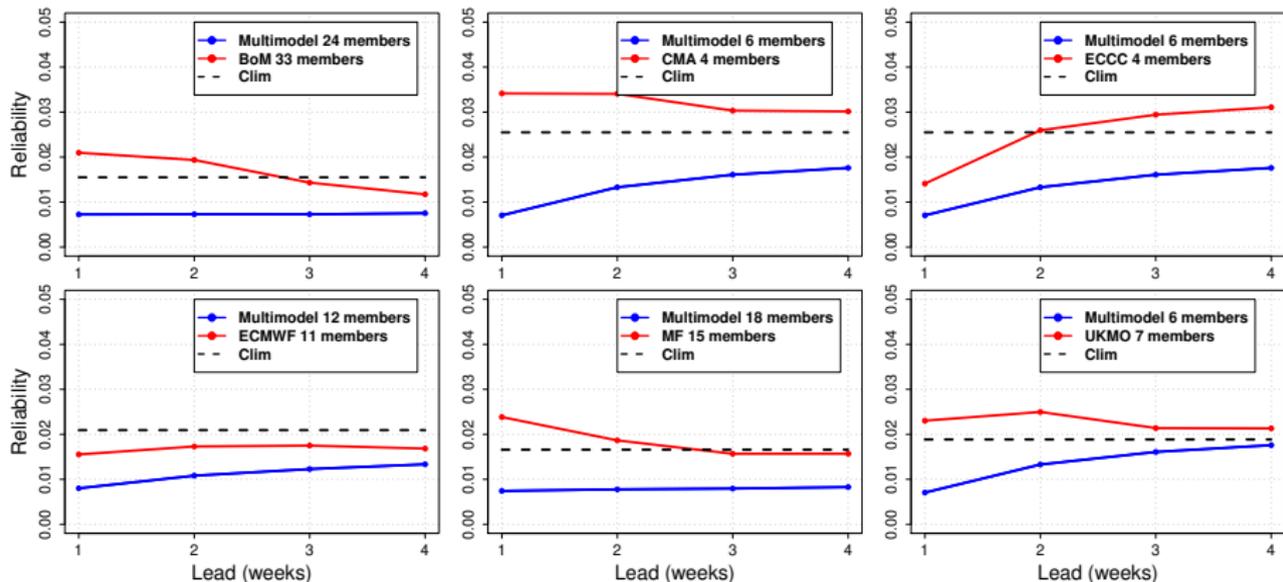
Fig. 6 : Comparison between multimodel and single model Brier Score reliability component at equivalent ensemble size for the upper 20% of weekly precipitation at the scale of the southwest tropical Pacific domain

# Modulation of skill by the MJO

Average score over the New Caledonia domain (163°E-169°E ; 23°S-19°S)



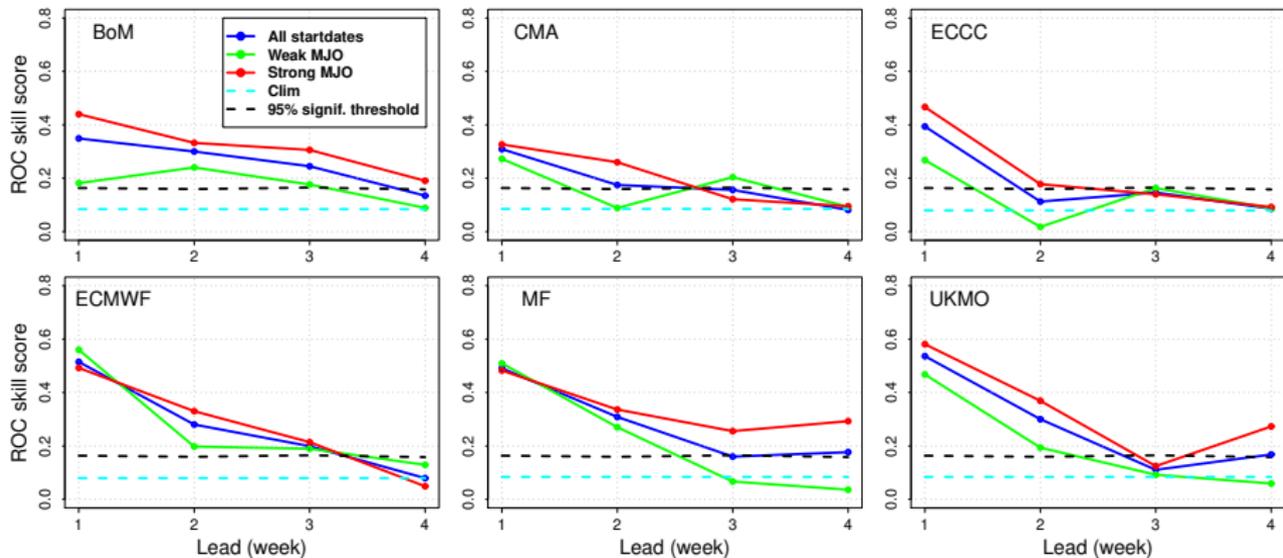Fig. 7 : Evolution of ROC skill score with lead time averaged over New Caledonia conditioned on initial MJO activity, for each of the 6 models. Weak MJO : 78 start dates. Strong MJO : 138 start dates.
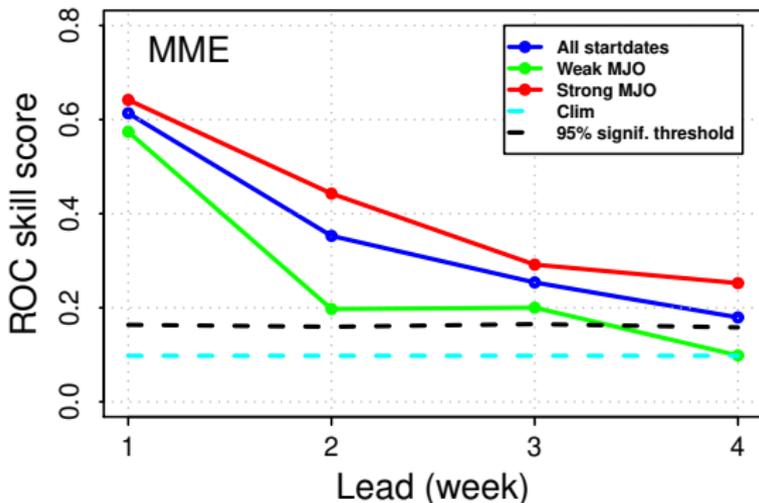
Fig. 8 : Evolution of ROC skill score with lead time averaged over New Caledonia conditioned on initial MJO activity, in the 24-member MME. Weak MJO : 78 start dates. Strong MJO : 138 start dates.

# Statistical-dynamical prediction

Predictors and method

## ENSO

*N*34 : 90-day mean of the Niño 3.4 box average SST anomaly in ERA-Interim prior to the start date

## MJO

*RMM*1 and *RMM*2 indices from ERA-Interim and S2S reforecasts, averaged on target week

## Logistic regression

- Probability of weekly precipitation in upper 20% at a grid point : $p$
- 3-predictor example :

$$ln(\frac{p}{1-p}) = b_0 + b_1 RMM1$$
$$+ b_2 RMM2 + b_3 N34$$

- Leave-one-year-out cross validation, perfect prog approach

## Statistical-dynamical models

- ENSO (*N*34) from ERA-i only :
  **Purely statistical**
- ENSO and MJO (*RMM*1 and *RMM*2) from ERA-i :
  **Purely statistical**
  **Theoretical limit**
- ENSO from ERA-i, MJO from S2S reforecasts :
  **Statistical-dynamical**
  **Real-time forecasting situation**

# Statistical-dynamical prediction

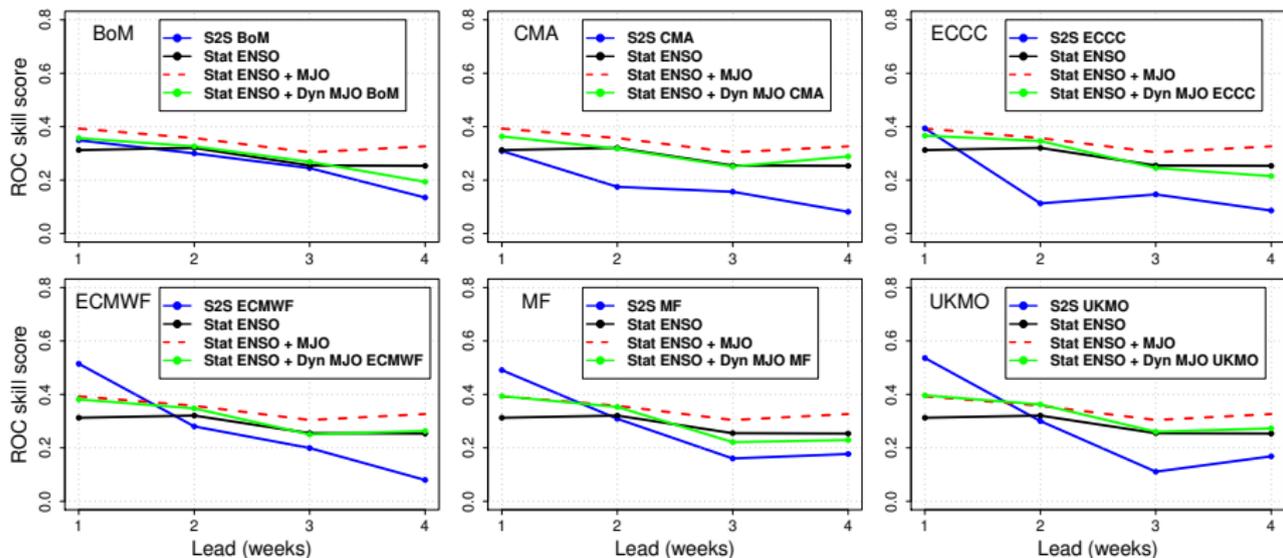Average score over the New Caledonia domain (163°E-169°E ; 23°S-19°S)



Fig. 9 : Spatial average (New Caledonia domain) of the ROC skill score obtained from the raw S2S output (blue), the ENSO-based statistical model (black), the ENSO-MJO based statistical model (dashed red) and the ENSO-MJO based statistical-dynamical model (green)

# Statistical-dynamical prediction with the MME MJO reforecasts

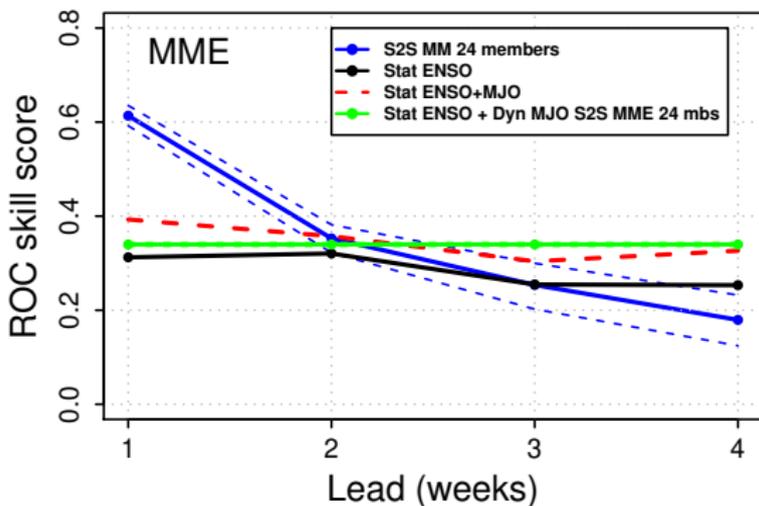Average score over the New Caledonia domain (163°E-169°E ; 23°S-19°S)



Fig. 10 : Spatial average (New Caledonia domain) of the ROC skill score obtained from the raw 24-member MME S2S output (blue), the ENSO-based statistical model (black), the ENSO-MJO based statistical model (dashed red) and the ENSO-MJO based statistical-dynamical model with 24-member MME MJO reforecasts (green)

# Conclusions

## The MME increases reforecast scores

- Thanks to larger ensemble size and increased diversity
- If we remove the ensemble size effect (fair comparaison) :
  - The MME is not better than the best models for the ROC skill score
  - The MME is still more reliable than any individual model

## Modulation of skill by the MJO in New Caledonia

- Skill is higher for initially active MJO
- More skill differences with initial MJO conditions in the MME than in individual models

## Statistical-dynamical prediction

- Baseline skill comes from ENSO-related SST initial conditions
- Statistical-dynamical forecasts with MME MJO provide additional skill at weeks 3 and 4

# Take-home message

Is it worth using a multimodel for our specific S2S forecasting case ?

## Benefits of the multimodel

- Increased reforecast scores (ROC skill score, reliability)
- Increased sensitivity to initial MJO conditions → easier identification of forecasts of opportunity
- Better MJO predictor for statistical-dynamical prediction

## But...

- In equivalent size comparison, the MME does not perform better than ECMWF and UKMO

Specq, D., L. Batté, M. Déqué and C.Ardilouze (2019). Multimodel forecasting of precipitation at subseasonal time scales in the tropical Southwest Pacific. Submitted to *JGR : Atmospheres* as part of the S2S Special Issue

# Thank you for your attention



Questions before coffee ?
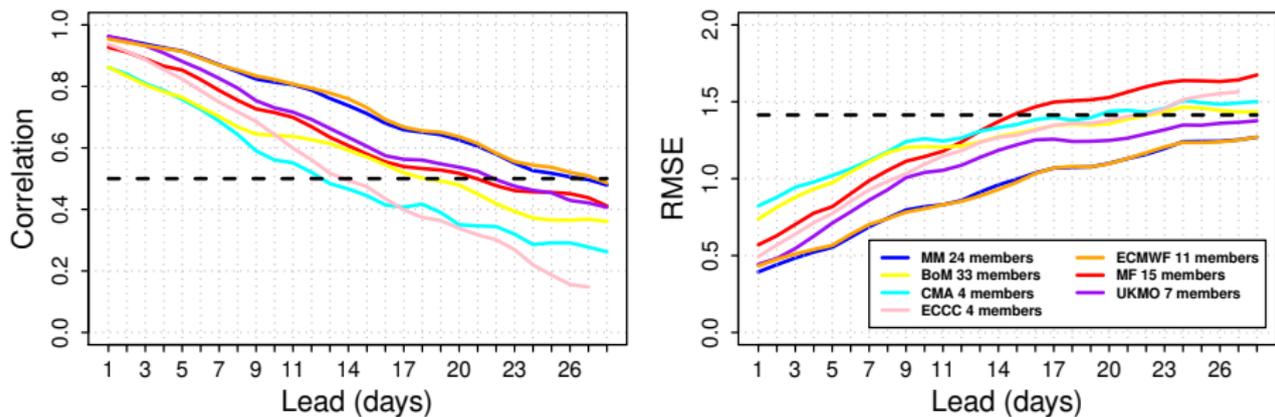
# MJO prediction in the S2S models



Fig. 11 : (a) MJO bivariate correlation (RMM1 and RMM2) (b) MJO bivariate RMSE,
for the individual models and the 24-member multimodel (median)

# S2S reforecasts

| Attributes | BoM | CMA | ECCC | ECMWF | Météo-France | UKMO |
|---|---|---|---|---|---|---|
| **Length (days)** | 62 | 60 | 32 | 46 | 61 | 60 |
| **Reforecast** | Fix | Fix | On the fly | On the fly | Fix | On the fly |
| **Reforecast period** | 1981-2013 | 1994-2014 | 1995-2014 | 1996-2015 | 1993-2014 | 1993-2015 |
| **Reforecast fre-quency** | 4/month | Daily | Weekly | 2/week | 4/month | 4/month |
| **Reforecast size** | 33 | 4 | 4 | 11 | 15 | 7 |

Table 1 : Reforecast attributes for the 6 models from the S2S database

# Multimodel ensemble construction

Correspondence between start dates

| MF | BoM | CMA | ECCC | ECMWF | UKMO |
|-------|-------|-------|-------|-------|-------|
| **01-01** | 01-01 | 01-01 | 01-04 | 12-31 | 01-01 |
| **01-08** | 01-06 | 01-08 | 01-11 | 01-07 | 01-09 |
| **01-15** | 01-16 | 01-15 | 01-18 | 01-14 | 01-17 |
| **01-22** | 01-21 | 01-22 | 01-25 | 01-21 | 01-25 |
| **02-01** | 02-01 | 02-01 | 02-01 | 02-01 | 02-01 |
| **02-08** | 02-06 | 02-08 | 02-08 | 02-08 | 02-09 |
| **02-15** | 02-16 | 02-15 | 02-15 | 02-15 | 02-17 |
| **02-22** | 02-21 | 02-22 | 02-22 | 02-22 | 02-25 |
| **12-01** | 12-01 | 12-01 | 11-30 | 12-01 | 12-01 |
| **12-08** | 12-06 | 12-08 | 12-07 | 12-08 | 12-09 |
| **12-15** | 12-16 | 12-15 | 12-14 | 12-15 | 12-17 |
| **12-22** | 12-21 | 12-22 | 12-21 | 12-22 | 12-25 |

Table 2 : Correspondence between the Météo-France (MF) reference
start dates and the start dates of the five other models

# Comparison between multimodel and individual model skill

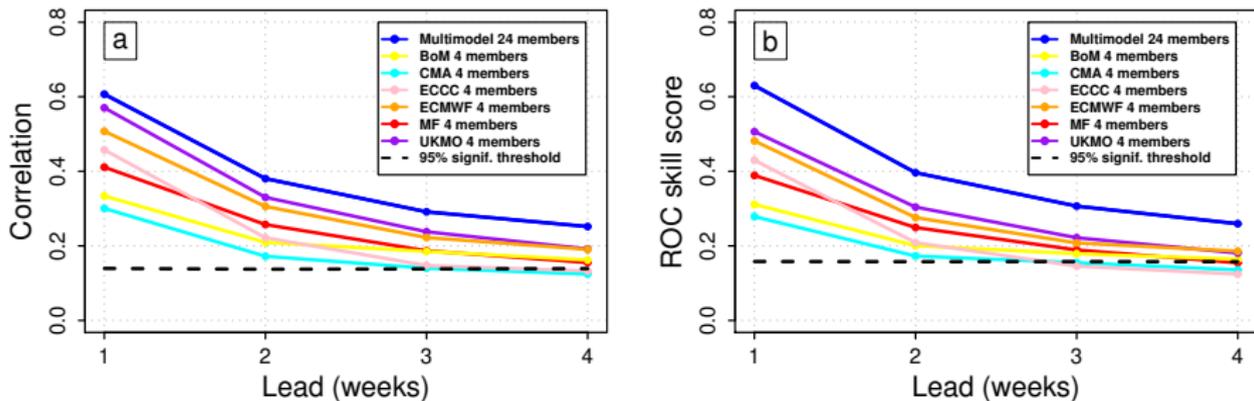Average score over the SW tropical Pacific domain



Fig. 12 : Spatial mean of (a) correlation of weekly rainfall (b) ROC skill score of the upper 20% of weekly precipitation, for the southwest tropical Pacific domain

# Comparison between multimodel and individual model skill

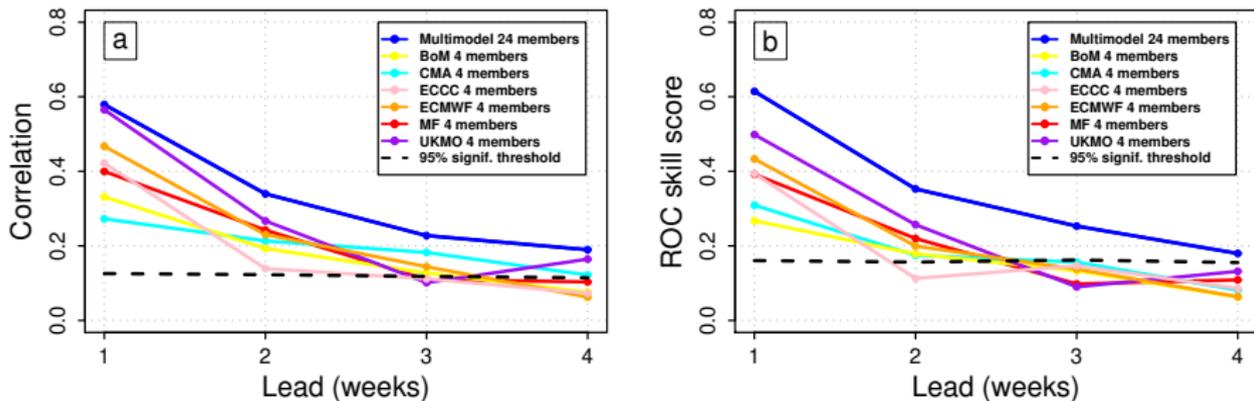Average score over the New Caledonia domain



Fig. 13 : Spatial mean of (a) correlation of weekly rainfall (b) ROC skill score of the upper 20% of weekly precipitation, for the New Caledonia domain

# Benefits of the MME on reliability
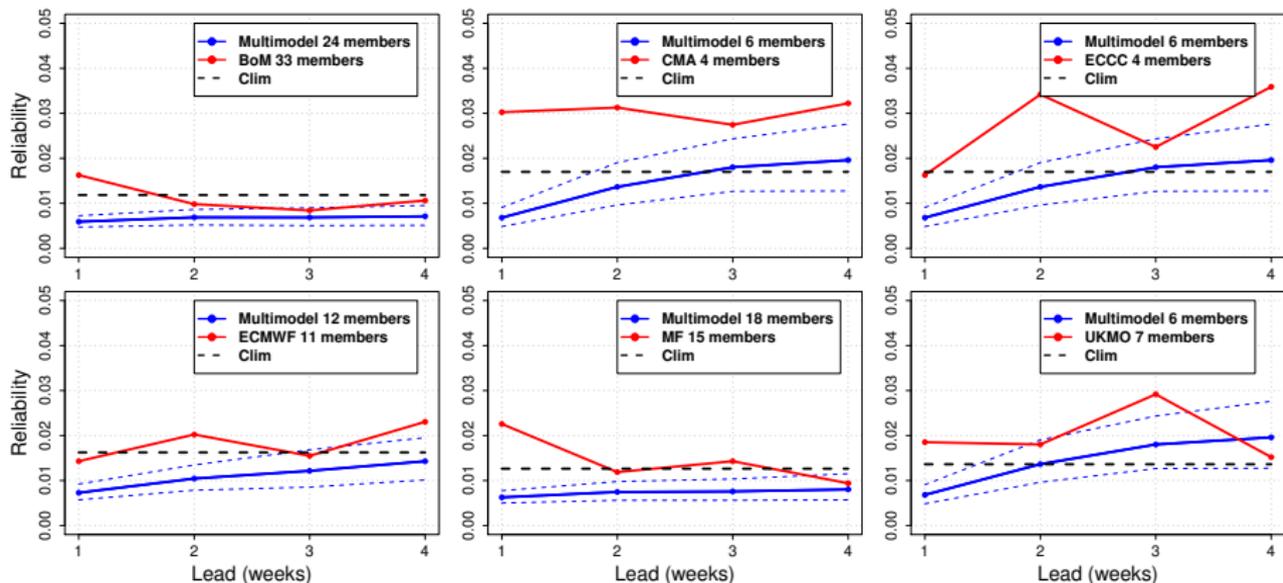
Average score over the New Caledonia domain

Fig. 14 : Comparison between multimodel and single model Brier Score reliability component at equivalent ensemble size for the upper 20% of weekly precipitation at the scale of the New Caledonia domain