An overview of subseasonal forecasting research at CNRM in the S2S project

PISSARO Workshop – Météo-France, DIROI – 2 June 2022

Damien Specq, Constantin Ardilouze, Lauriane Batté and the PASTEL team

Météo-France, Centre National de Recherches Météorologiques

Overview of S2S research at CNRM

Research topic #1 : Developing the S2S forecasting system

Research topic #2 : Improving the forecasts *a posteriori*

Research topic #3 : When can we expect “good” forecasts?

Future prospects

Research topic #1: **Developing the S2S forecasting system**

S2S sets

- **Real time**
- Reforecasts

Statistical process

- Instantaneous and accumulated
- **Daily averaged**

Origins

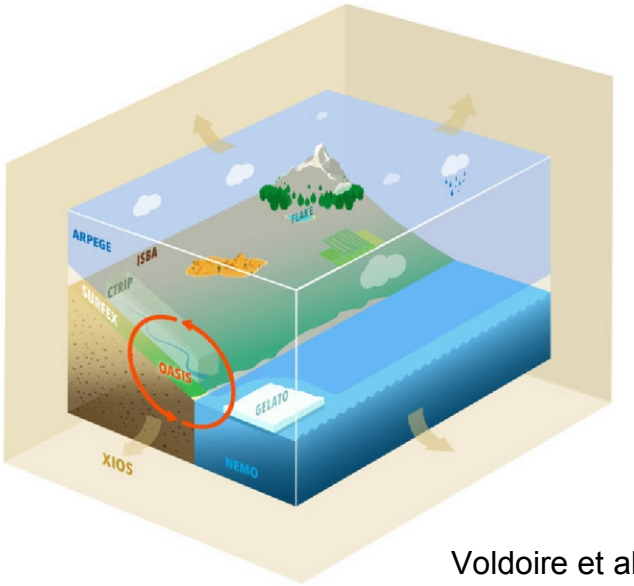
- BoM
- CMA
- ECMWF
- HMCR
- IAP-CAS
- ISAC-CNR
- JMA
- **Météo France**
- NCEP
- UKMO
- ECCC
- KMA

➢ CNRM subseasonal real-time forecasts and re-forecasts are issued weekly for research purposes and provided to the S2S database

➢ The subseasonal forecasting system stems from the seasonal forecasting system

➢ Built from the global coupled model CNRM-CM

➢ 2 versions : 2015, upgraded in 2020 (Ardilouze et al. 2021)



CNRM-CM

Voldoire et al (2019)

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Research topic #2: **Improving the forecasts *a posteriori***

- Multi-model combination
- Statistical-dynamical prediction

Multimodel Forecasting of Precipitation at Subseasonal Timescales Over the Southwest Tropical Pacific

Damien Specq[1,2], Lauriane Batté[1], Michel Déqué[1], and Constantin Ardilouze[1]

[1]CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France, [2]Direction de la recherche, École des Ponts, Paris, France

Climate Dynamics (2020) 55:1913–1927
https://doi.org/10.1007/s00382-020-05355-7

Check for updates

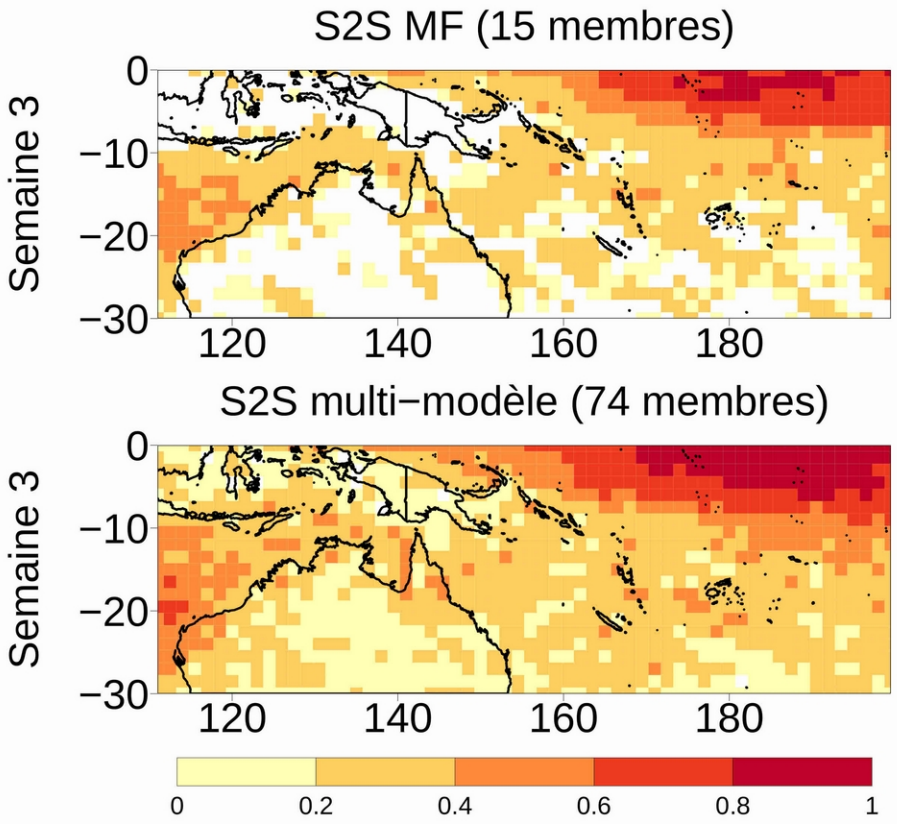
Improving subseasonal precipitation forecasts through a statistical–dynamical approach : application to the southwest tropical Pacific

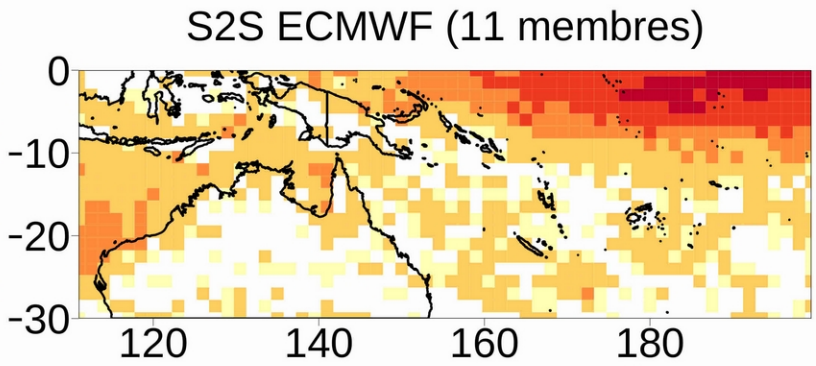
Damien Specq[1] · Lauriane Batté[1]

Received: 19 December 2019 / Accepted: 3 July 2020 / Published online: 22 July 2020

Multi-model combination

➢ Heavy rainfall weeks (> 80th percentile) are better detected with the multi-model than with individual models. Illustration for week 3 lead time over the southwest tropical Pacific.



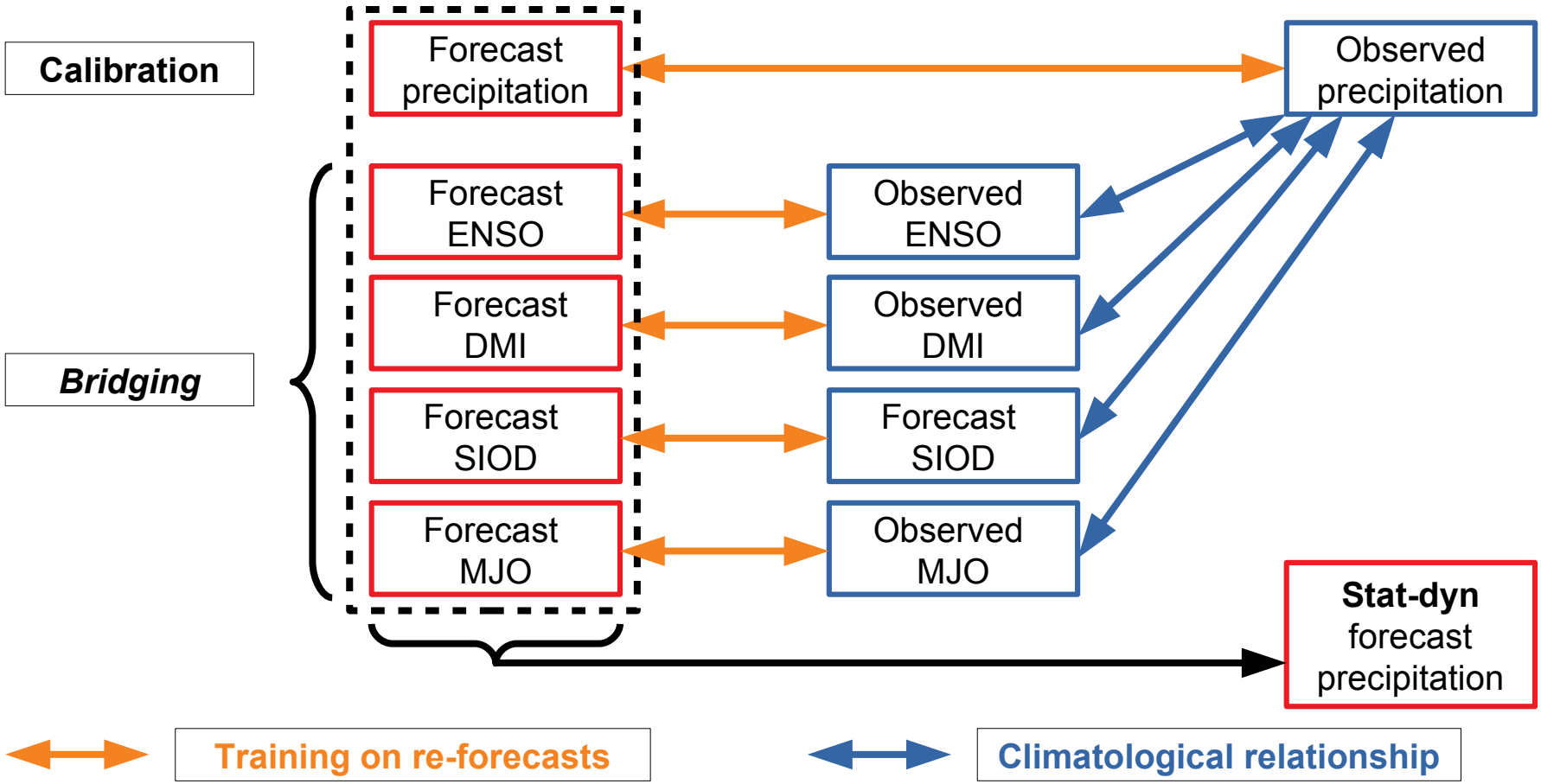


ROC skill score (=discrimination) of S2S forecasts of the upper quintile of weekly precipitation at lead time week 3.
Reference: MSWEP. Period: DJF 1996-2013.

Statistical-dynamical prediction

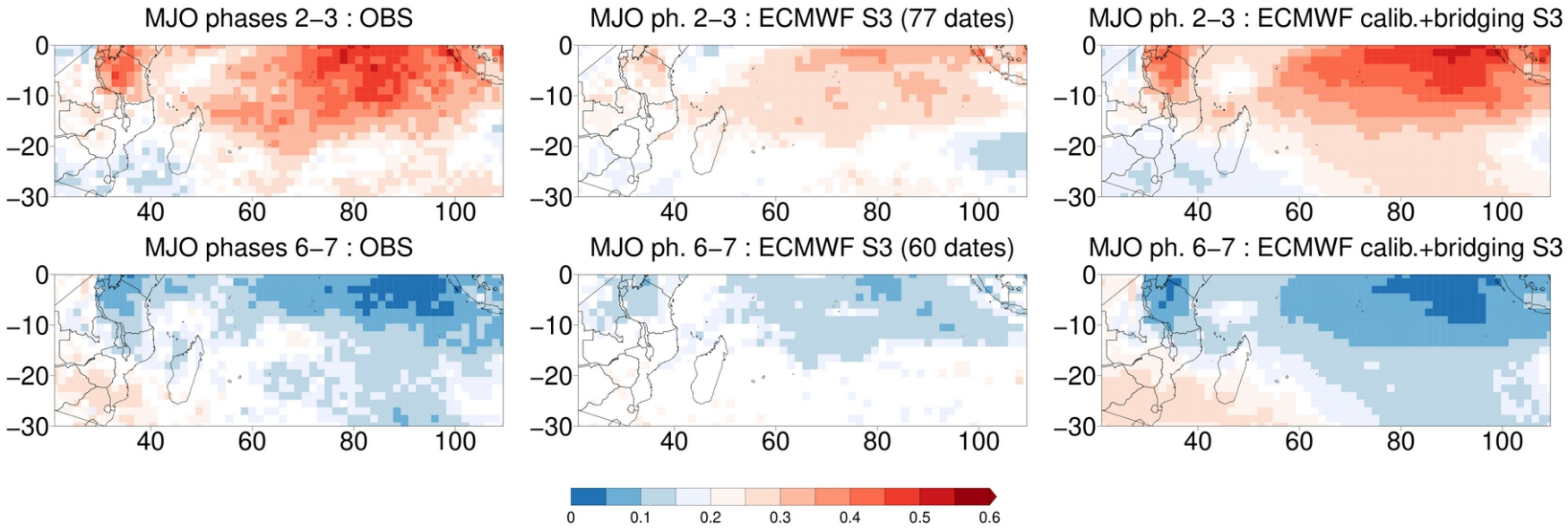
Goals :

- Harvesting additional information from the model large-scale predictors
- Improving the calibration of probabilistic forecasts (= better representation of uncertainty)



Statistical-dynamical prediction

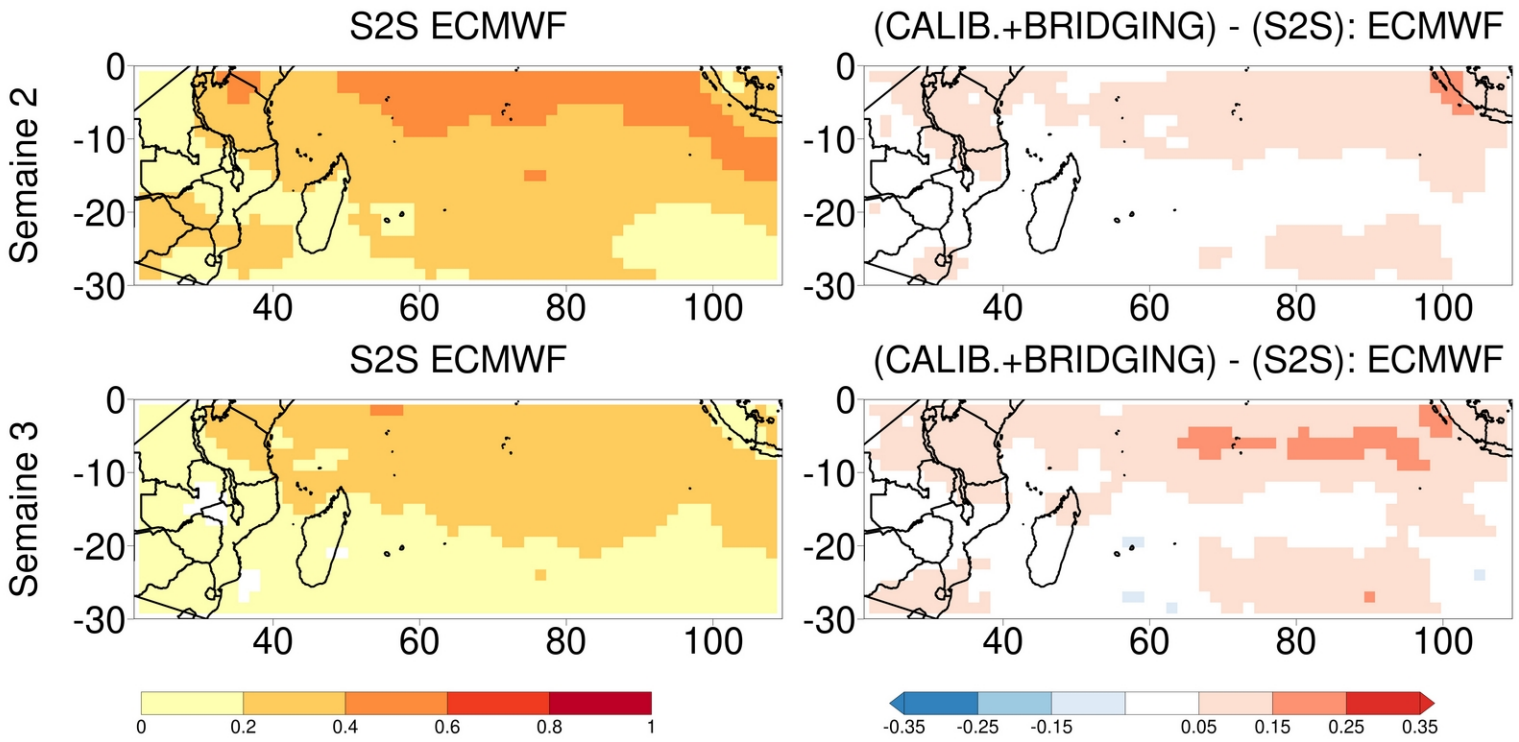
➢ The statistical-dynamical scheme leads to a better representation of the link between large-scale variability and precipitation in the model's world



▲ Frequency of the upper quintile of weekly precipitation in MJO phases 2-3 et 6-7 in the observation world (GPCP) and in week 3 ECMWF S2S reforecasts, before and after implementing the statistical-dynamical scheme.
Period: NDJFMA 2000-2001 to 2019-2020.

Statistical-dynamical prediction

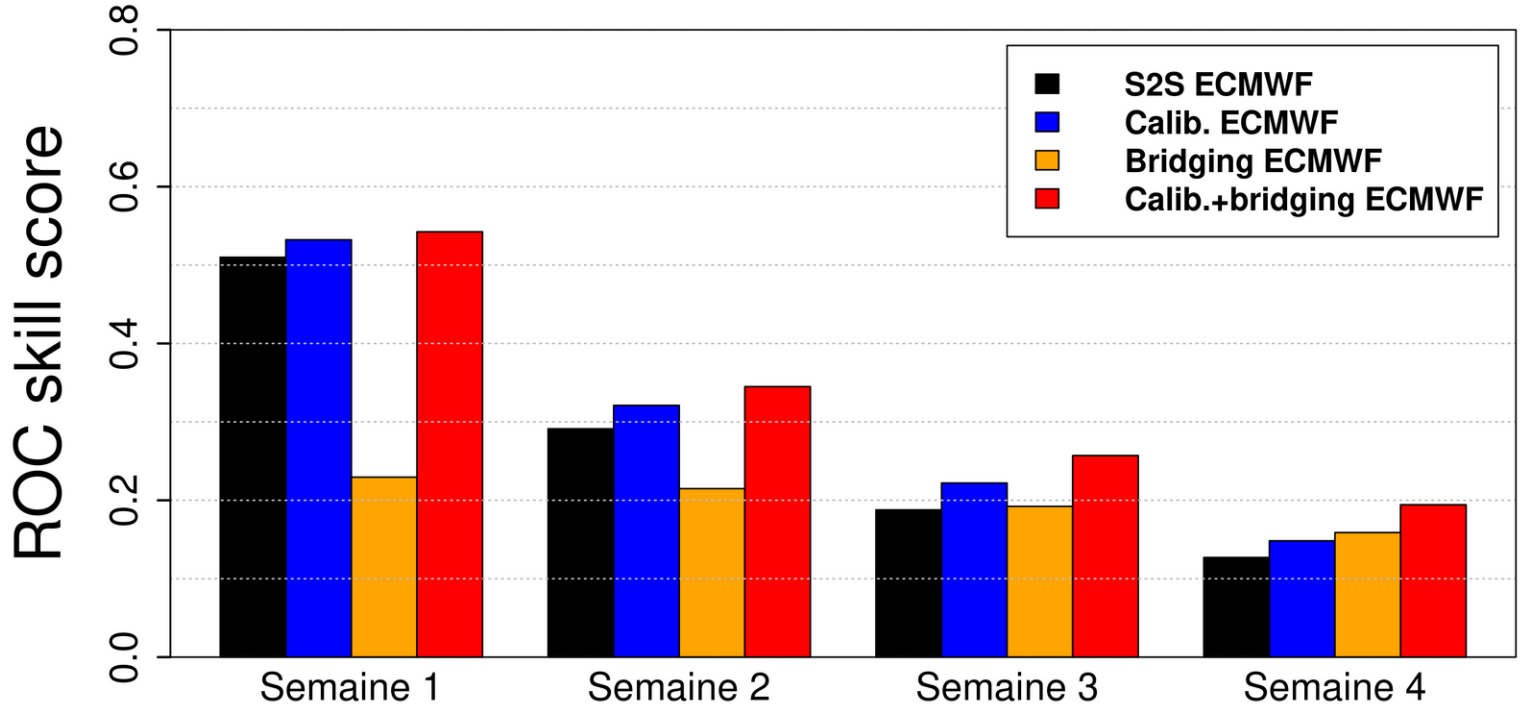
➢ Weekly periods of heavy precipitation are better detected, compared to the raw S2S forecasts. Shown here at grid point level.



▲ Left: ROC skill score of week-2 and week-3 S2S reforecasts for the upper quintile of weekly precipitation.
Right: ROC skill score difference between the calibration+bridging and the raw S2S reforecasts
Reference: GPCP. Period: NDJFMA 2000-2001 to 2019-2020

Statistical-dynamical prediction

➢ Weekly periods of heavy precipitation are better detected, compared to the raw S2S forecasts. Shown here at the scale of the southwest Indian ocean domain.



▲ ROC skill score of week-1 to week-4 S2S reforecasts for the upper quintile of weekly precipitation, before any stat-dyn scheme (black), with calibration (blue), with *bridging* (orange), with calibration + *bridging* (red).
Reference: GPCP. Period: NDJFMA 2000-2001 to 2019-2020

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Research topic #1 : Developing the S2S forecasting system

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Future prospects

Research topic #3: **When can we expect "good" forecasts?**

- Identification of subseasonal "windows of opportunity" (Mariotti et al. 2020)
- Evaluating forecasts with an opportunity-oriented framework
- Case studies

Forecasting West African Heat Waves at Subseasonal and Seasonal Time Scales

LAURIANE BATTÉ, CONSTANTIN ARDILOUZE, AND MICHEL DÉQUÉ

CNRM UMR 3589 (Météo-France/CNRS), Toulouse, France

(Manuscript received 20 July 2017, in final form 10 January 2018)

Weather Clim. Dynam., 2, 1033–1049, 2021
https://doi.org/10.5194/wcd-2-1033-2021

Weather and Climate Dynamics — Open Access — EGU

Flow dependence of wintertime subseasonal prediction skill over Europe

Constantin Ardilouze[1], Damien Specq[1], Lauriane Batté[1], and Christophe Cassou[2]

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ARTICLE

Atmospheric Science Letters — RMetS

Do subseasonal forecasts take advantage of Madden–Julian oscillation windows of opportunity?

Damien Specq | **Lauriane Batté**

Windows of opportunity

- Identification of the **situations when the performance of subseasonal forecasts is enhanced**

  Example : Week-3 forecasts of T2m over Europe in DJF are better when initialization takes place with **a strong North Atlantic Oscillation signal** (Ardilouze et al. 2021)

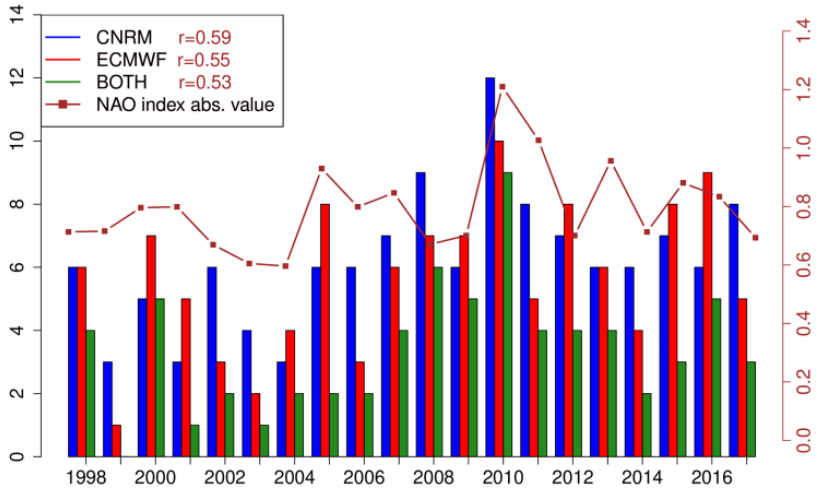


Figure 4. Yearly number of skillful forecasts for CNRM (blue), ECMWF (red) and both systems (green) computed on EUR week 3 temperature forecasts. The broken brown line shows the absolute value of the winter NAO index derived from ERA5 (see text). The "*r*" values reported in the legend correspond to the correlation of this index with the yearly number of skillful forecasts.

Windows of opportunity

➢ Are forecasts more skillful at predicting extreme events when such events are favored by a precursor phenomenon? Not necessarily… (Specq et Batté 2022)

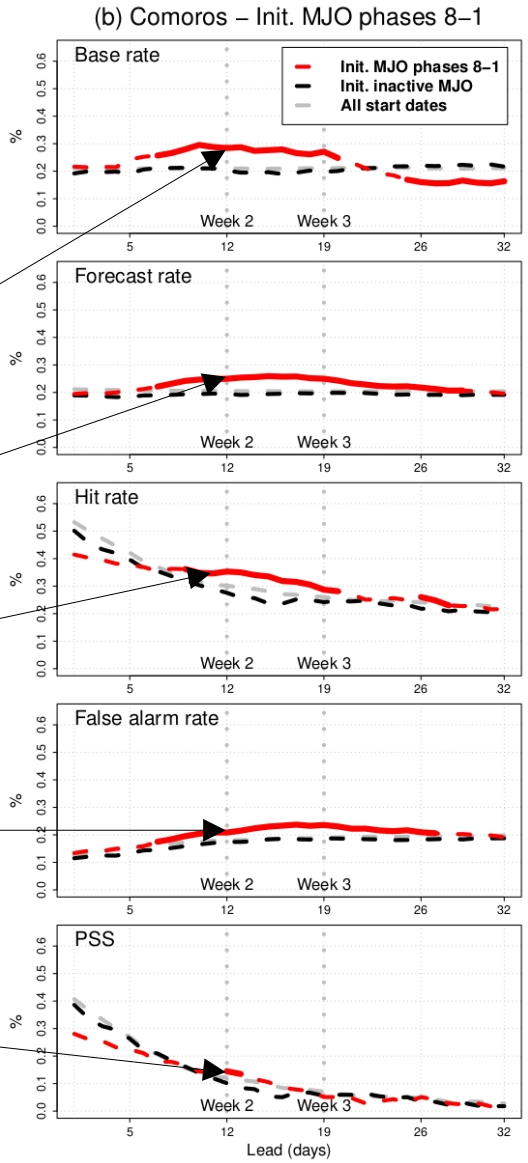
Increase in heavy precipitation over Comoros two weeks after MJO phases 8-1

The increase is well represented in S2S forecasts (ECMWF)

Significantly more events are detected at week-2, compared to forecasts initialized with inactive MJO

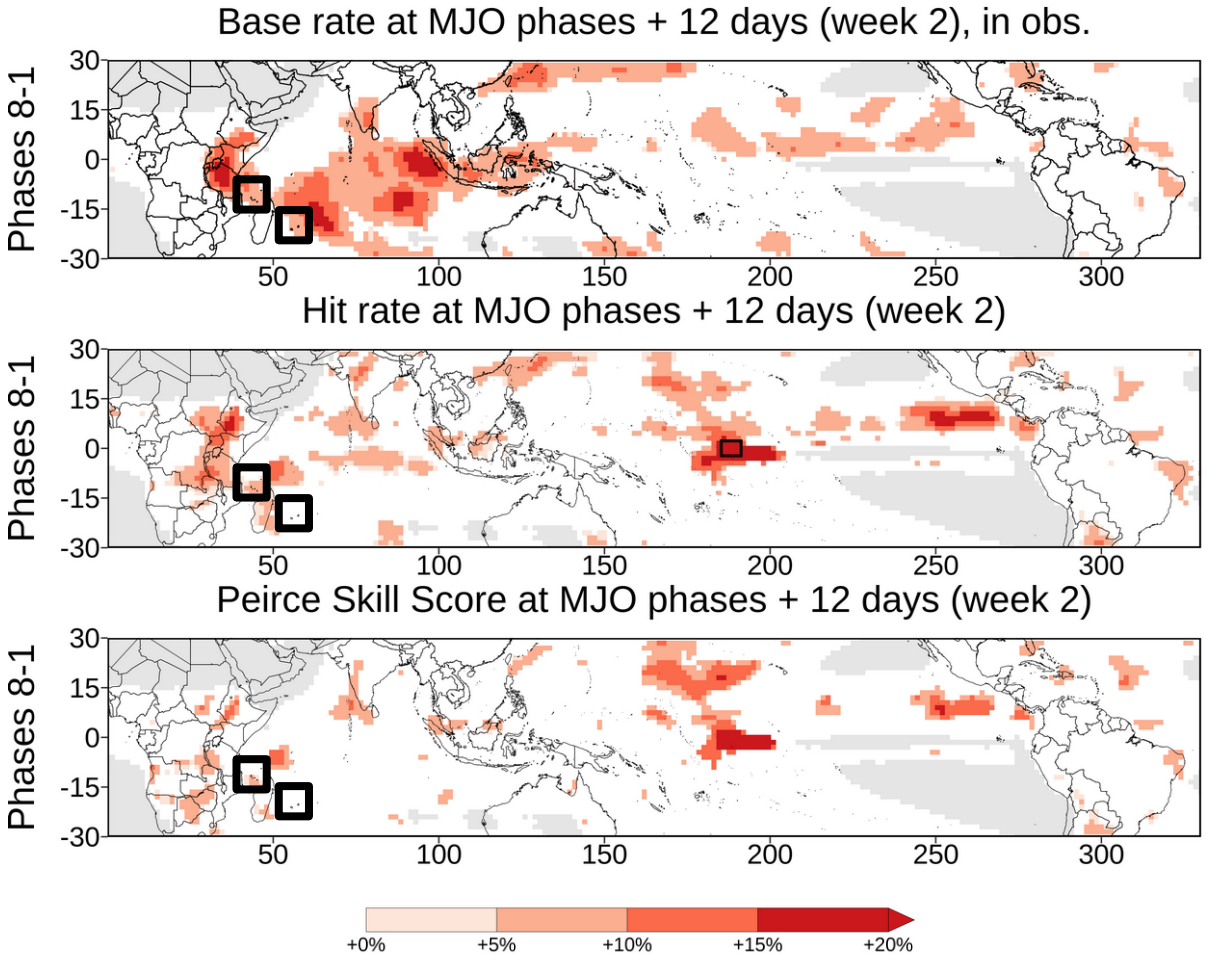
But there are also more false alarms!

The overall skill score (PSS) is not higher than without any MJO signal



Windows of opportunity

➢ Cases similar to Comoros are very frequent: forecasts do not necessarily show increased skill when initialized with a favorable signal, as more hits are often offset by more false alarms



◄ Increase in Base rate, Hit rate and PSS for forecasts initialized in MJO phases 8-1, compared to forecasts initialized with inactive MJO.

Windows of opportunity

➢ Another example: Mascareignes. ECMWF forecasts take advantage of the opportunity up to week-1, but do not at longer lead times

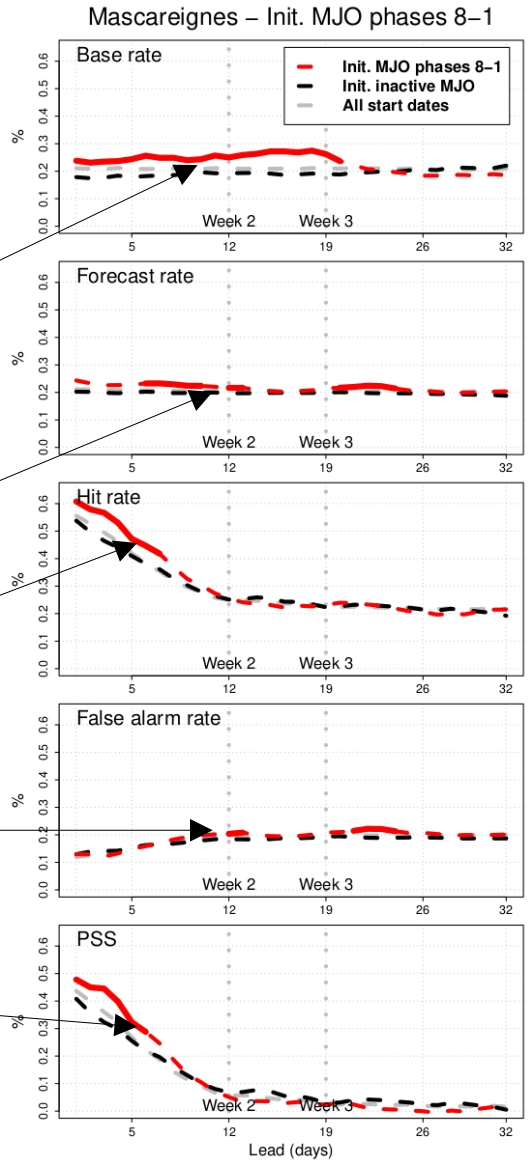
Increase in heavy precipitation over Mascareignes up to 3 weeks after MJO phases 8-1

The increase is not well represented in S2S forecasts

Significantly more events are detected up to week 1, but not beyond

Few false alarms

No PSS improvement beyond week 1



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Future prospects

- Taking into account the spatial and temporal scale of subseasonal extreme precipitation events to study the impact on predictability (PFE L. Pourchet)

- Attributing predictability to a large-scale phenomenon with idealized experimental settings

- Interpreting the ensemble forecasts with subseasonal scenarios (= a sequence of consistent subseasonal spells)

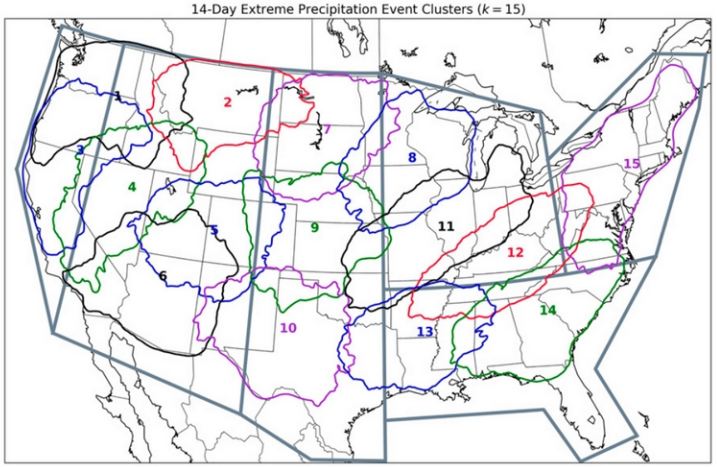
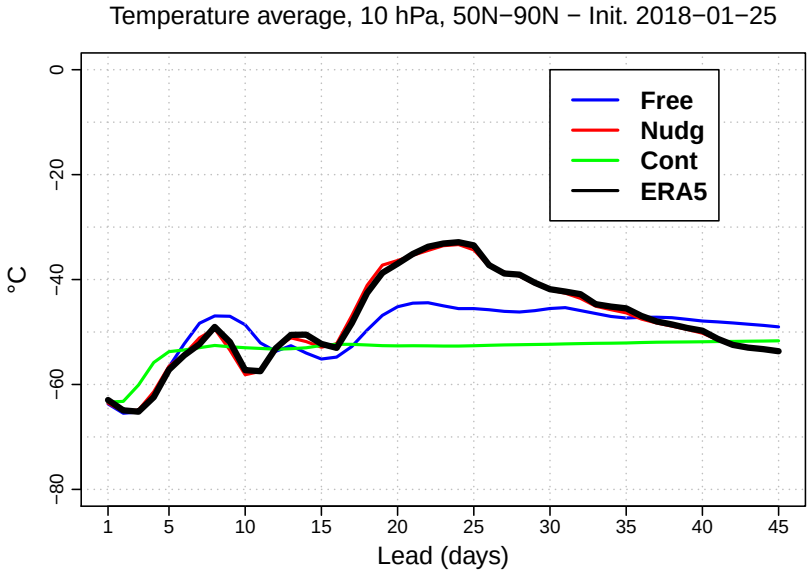


FIG. 9. Average polygons (colored contours) for k = 15 clusters across the CONUS for 14-day extreme precipitation events. Also shown are the regional boundaries defined by Jennrich et al. (2020) (gray outlines).

▲ Spatial clustering of subseasonal precipitation extremes over the United States (Dickinson et al. 2021)



▲ Stratospheric ensemble simulations nudged towards ERA5 reanalysis to study the predictability provided by Sudden Stratospheric Warmings (SNAPSI project)

Thank you for your attention!

References

Ardilouze, C. et al. Flow dependence of wintertime subseasonal prediction skill over Europe. *Weather and Climate Dynamics*, 2: 1033-1049 (2021)

Batté, L. et al. Forecasting West African Heat Waves at Subseasonal and Seasonal Time Scales. *Monthly Weather Review*, 146 : 889-906 (2018)

Dickinson, T.A. et al. Subseasonal-to-Seasonal Extreme Precipitation Events in the Contiguous United States: Generation of a Database and Climatology. *Journal of Climate* (2021)

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Moron, V. et al. Storm types in India: linking rainfall duration, spatial extent and intensity. *Phil. Trans. R. Soc. A*, 379: 20200137 (2021)

Specq, D. et al. Multimodel forecasting of precipitation at subseasonal timescales in the tropical Southwest Pacific. *Earth and Space Science*, 7: 9 (2020)

Specq, D. and L. Batté. Improving subseasonal precipitation forecasts through a statistical-dynamical approach : application to the southwest tropical Pacific. *Climate Dynamics* 55, 1913-1927 (2020)

Specq, D. and L. Batté. Do subseasonal forecasts take advantage of Madden-Julian oscillation windows of opportunity? *Atmospheric Science Letters*, e1078 (2022)

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Future prospects

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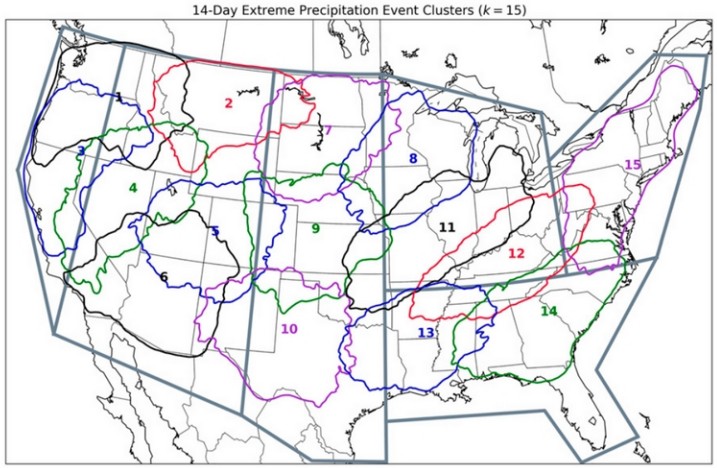

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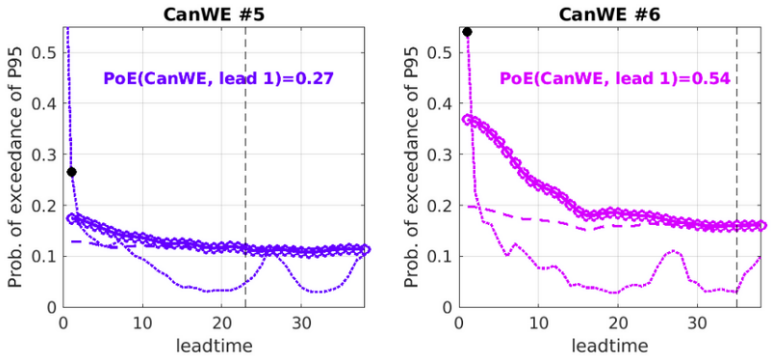
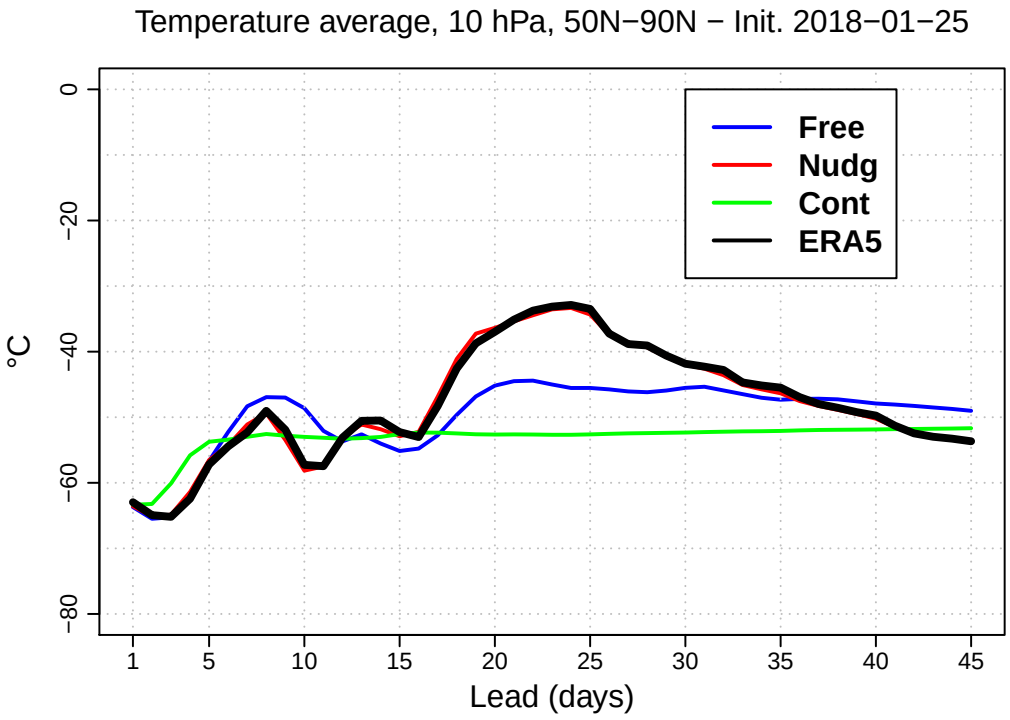


▲ Moron et al (2021) classify rainfall events over India into 6 types. S2S predictability changes with the spatial and temporal scale of the events.

Future prospects

➢ Attributing predictability to a large-scale phenomenon with idealized experimental settings



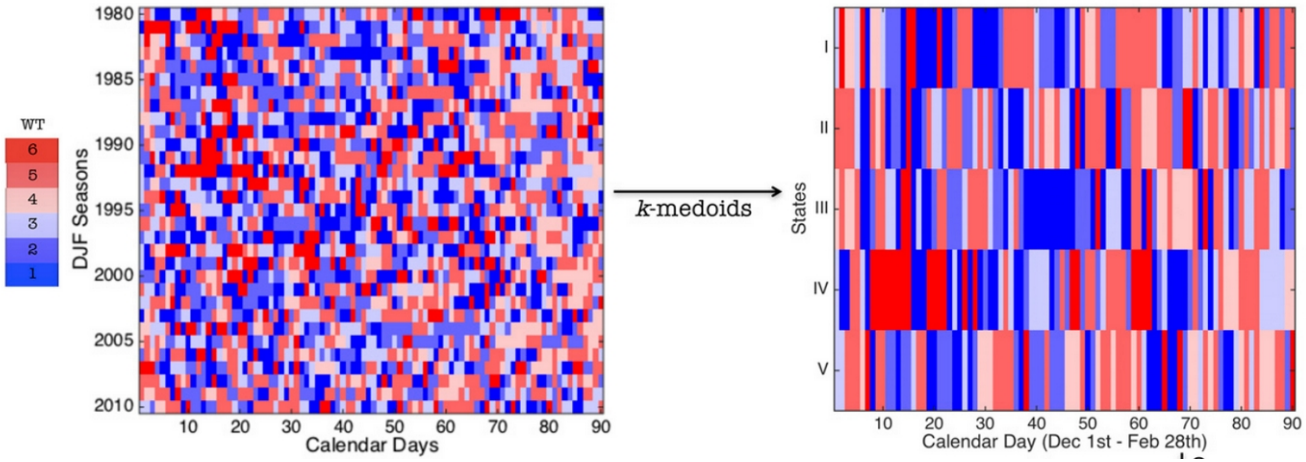
◄ Stratospheric ensemble simulations nudged towards ERA5 reanalysis to study the predictability provided by Sudden Stratospheric Warmings (SNAPSI project)

→ Upcoming attemps with **nudging towards observed MJO**

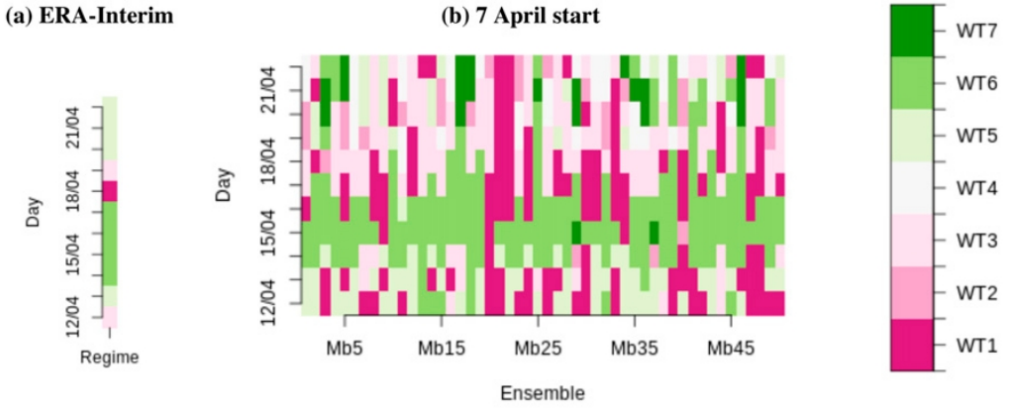
Future prospects

➢ Interpreting the ensemble forecasts with subseasonal scenarios (= a sequence of consistent subseasonal spells)

Example : subseasonal sequences of weather regimes



▲ Munoz et al (2016) over South America

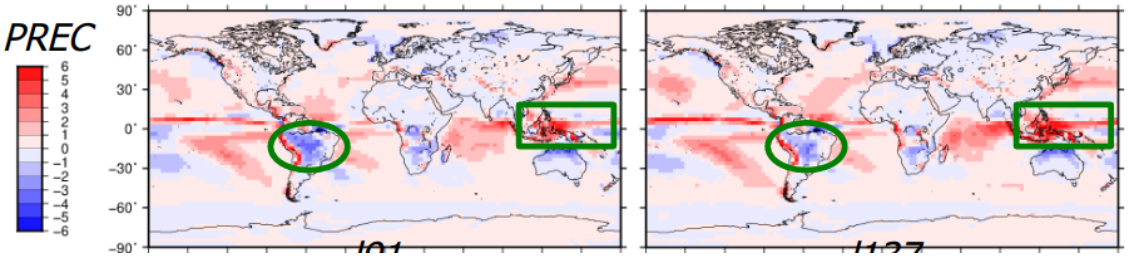


► Batté et al (2018) over West Africa (CNRM S2S forecast)

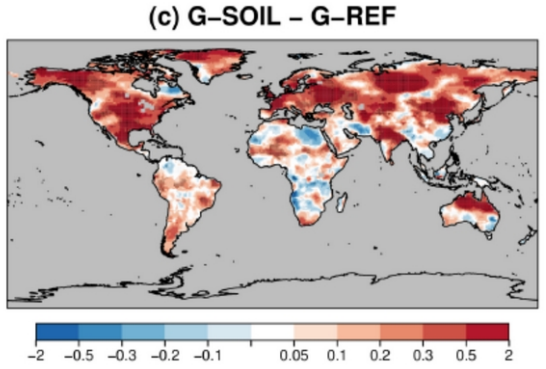
Research topic #1: **Developing the S2S forecasting system**

- Indirect development through **the seasonal forecasting system**

- Examples :
  - How to generate an ensemble forecast?
  - Increasing the resolution: ocean (1° to 0.25°), atmospheric vertical levels (91 to 137)
  - Research on atmospheric physics modeling
  - Research on land surface
  - Atmosphere-ocean coupled initialization



▲ Comparison of DJF seasonal forecast precipitation bias between 91 and 137 vertical levels (J-F. Guérémy)

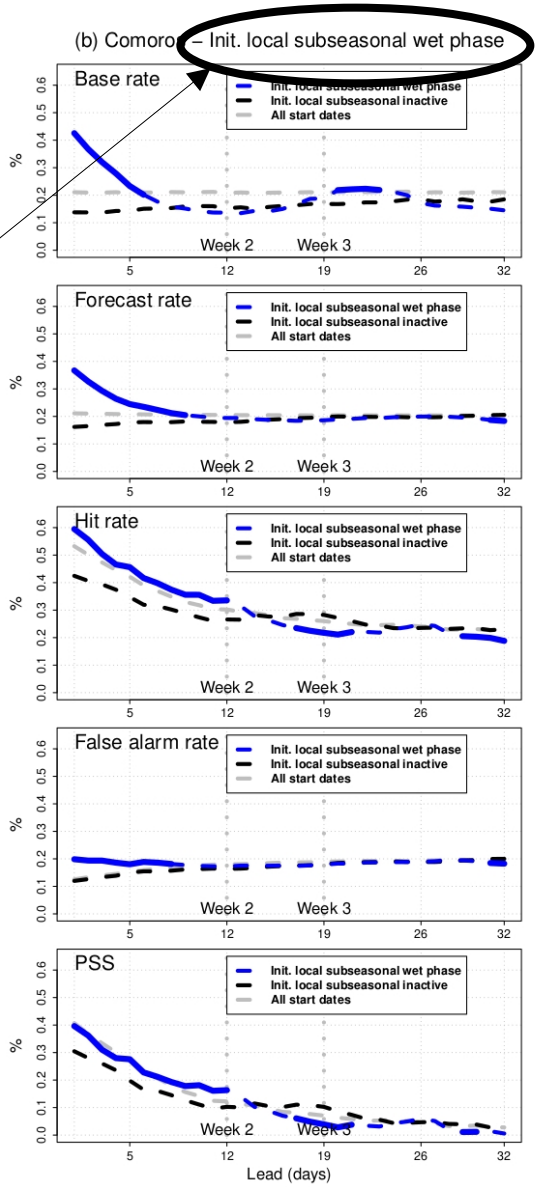


▲ Correlation improvement for JJA ensemble simulations of precipitation with constrained soil moisture (C. Ardilouze)

Future prospects

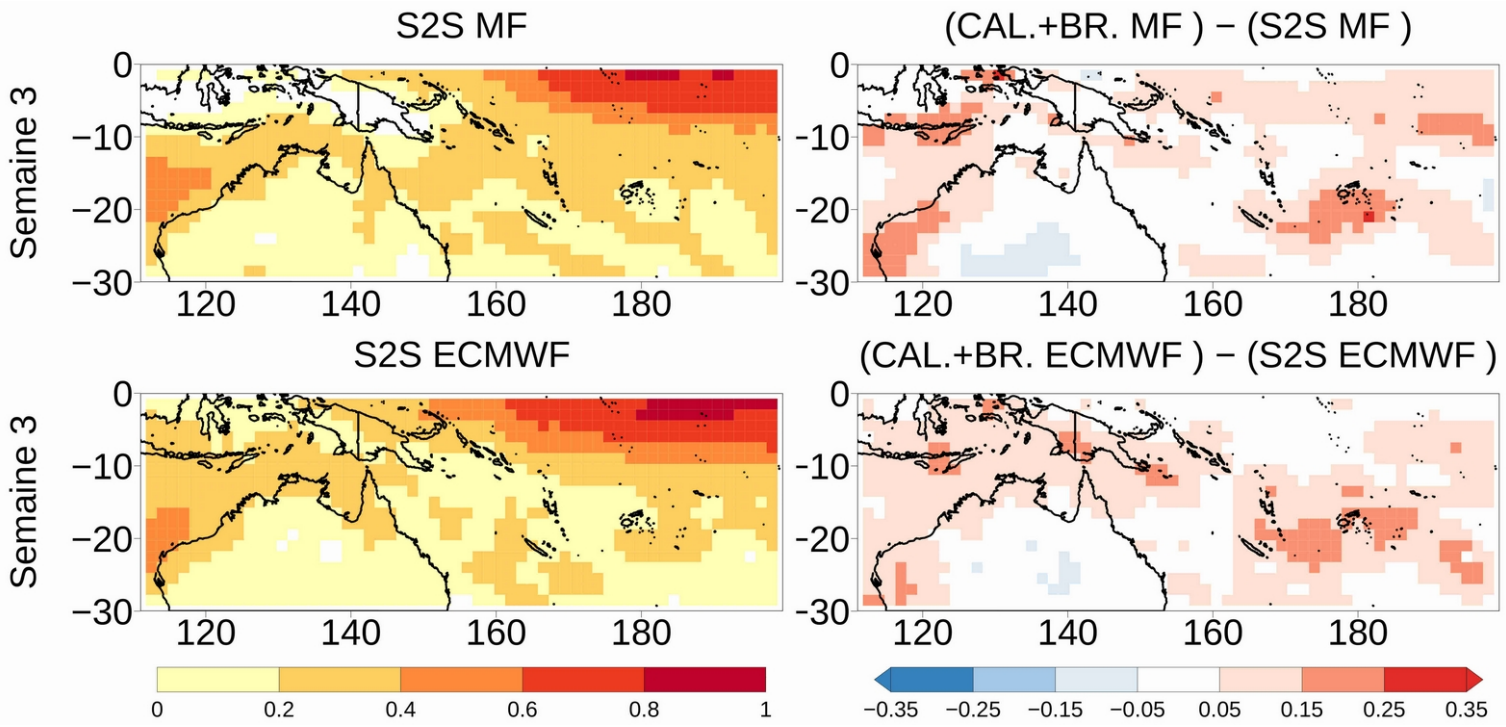
➢ Defining a local precursor to study the link between the initial value of this precursor and subseasonal windows of opportunity

Sub-selection of start dates when the local subseasonal index (from OLR) reaches a peak



La prévision statistico-dynamique

- Amélioration de la discrimination selon la zone (ROC skill score en points de grille)



▲ Gauche : ROC skill score des prévisions S2S du quintile supérieur des précipitations en semaine 3 (regroupements 3 x 3 points de grille).
Droite : Différence de ROC skill score entre avant et après application de l'approche statistico-dynamique (calibration + *bridging*).
Référence : MSWEP. Période : DJF 1996-2014)

Retour sur l'événement du 28-29 janvier 2018 en Nouvelle-Calédonie

- Conditions La Niña
- MJO en cours de propagation (active depuis fin novembre 2017)
- MJO en phase 6 lors de l'événement
- Lié à une dépression tropicale modérée (FEHI) en provenance du nord-ouest

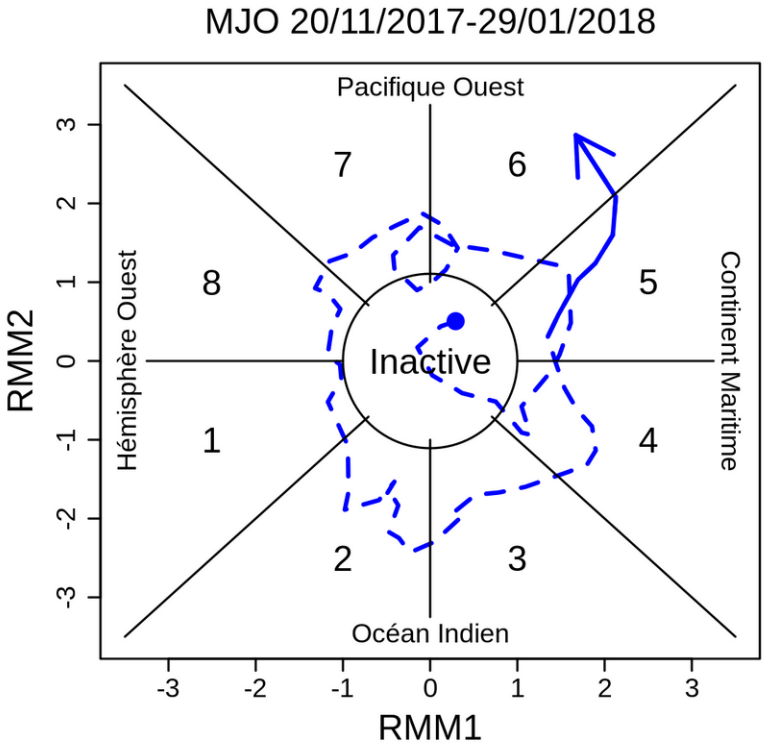
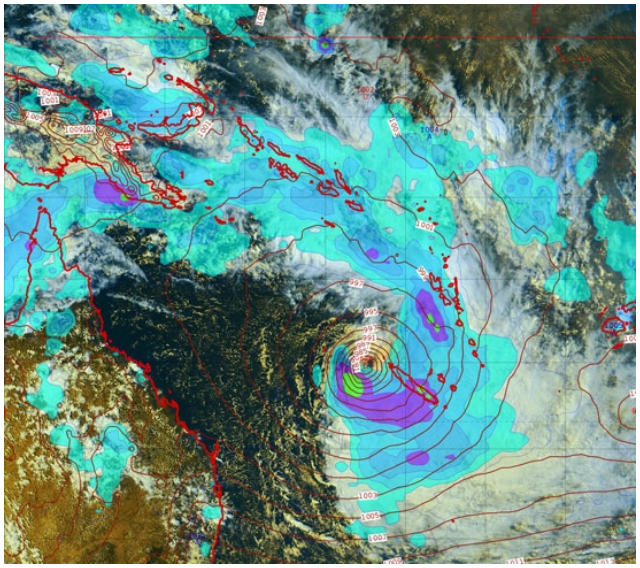
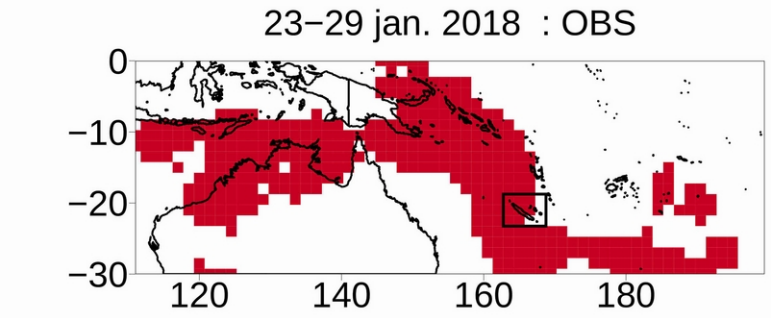


Image satellite, lame d'eau et pression au niveau de la mer associées à la dépression tropicale FEHI le 29/01/2018 17 h (Source : Météo-France). ▼

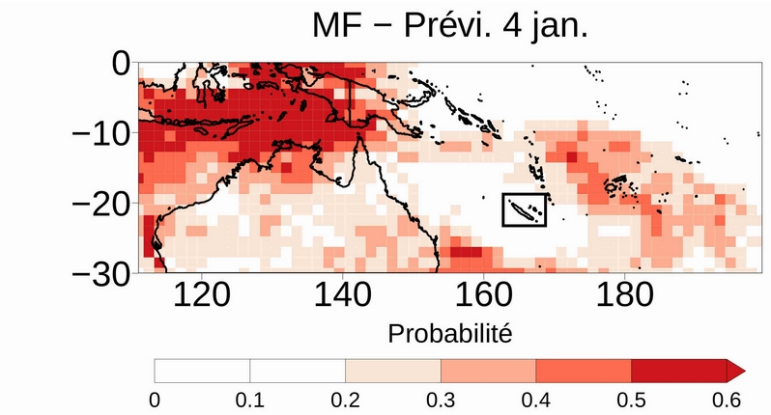


Étude de cas : semaine du 23 au 29 janvier 2018

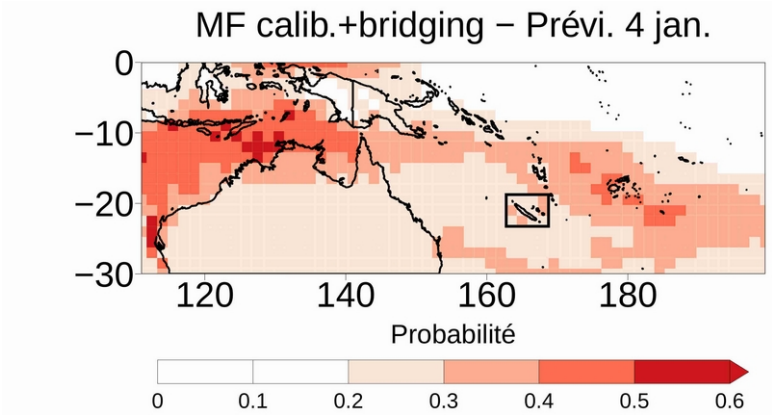
➢ Prévision du 4 janvier (semaine 3)



◄ Occurrence du quintile supérieur de la climatologie dans les observations GPCP



▲ Probabilité d'occurrence du quintile supérieur prévue au 4 janvier par le système S2S Météo-France.



▲ Probabilité d'occurrence du quintile supérieur prévue au 4 janvier par le système S2S Météo-France après approche statistico-dynamique.

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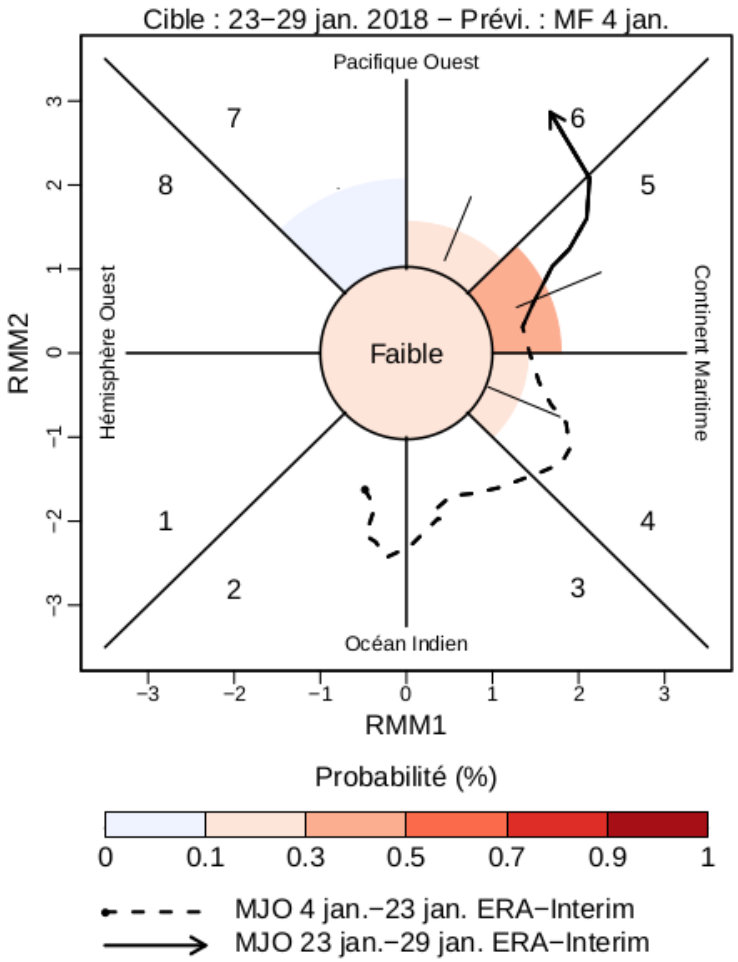
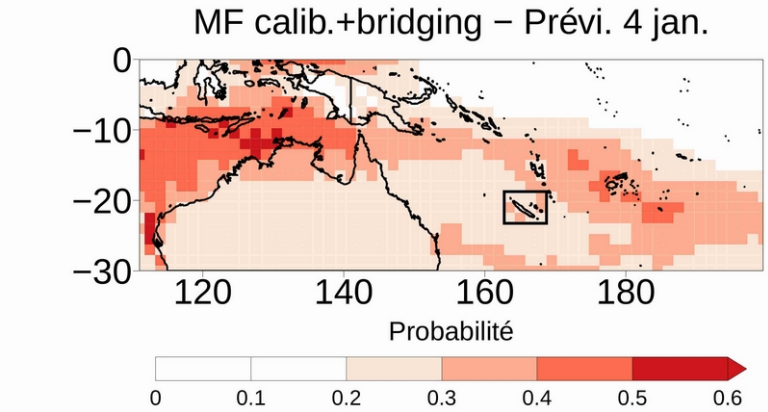


◄ Prévision probabiliste de la MJO sur la semaine cible par le système S2S de Météo-France initialisé au 4 janvier



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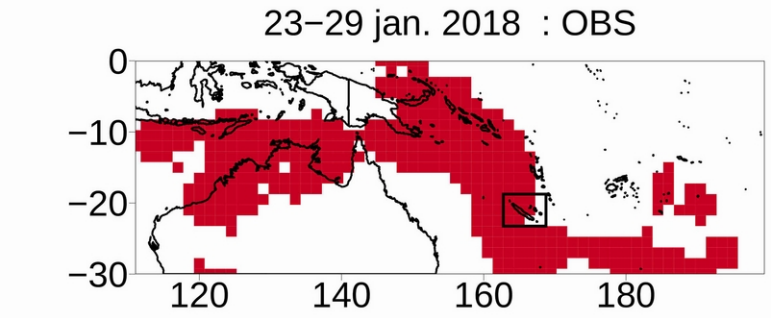
Étude de cas : semaine du 23 au 29 janvier 2018

➢ Prévision du 11 janvier (semaine 2)



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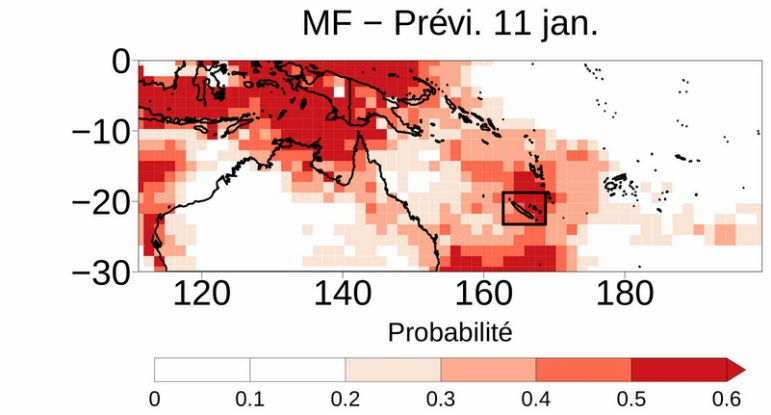
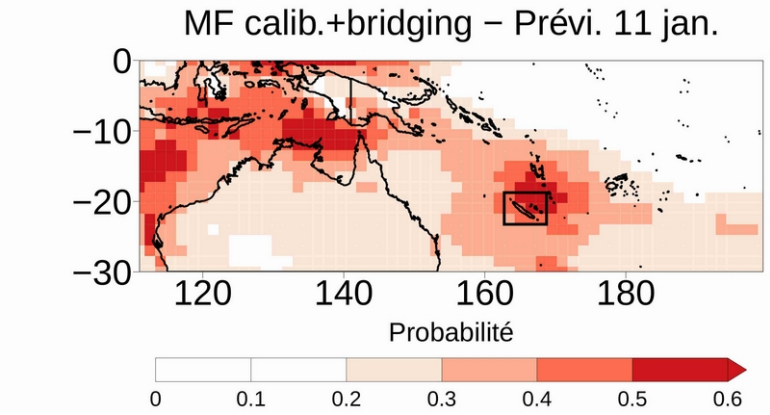


▲ Probabilité d'occurrence du quintile supérieur prévue au 11 janvier par le système S2S Météo-France.



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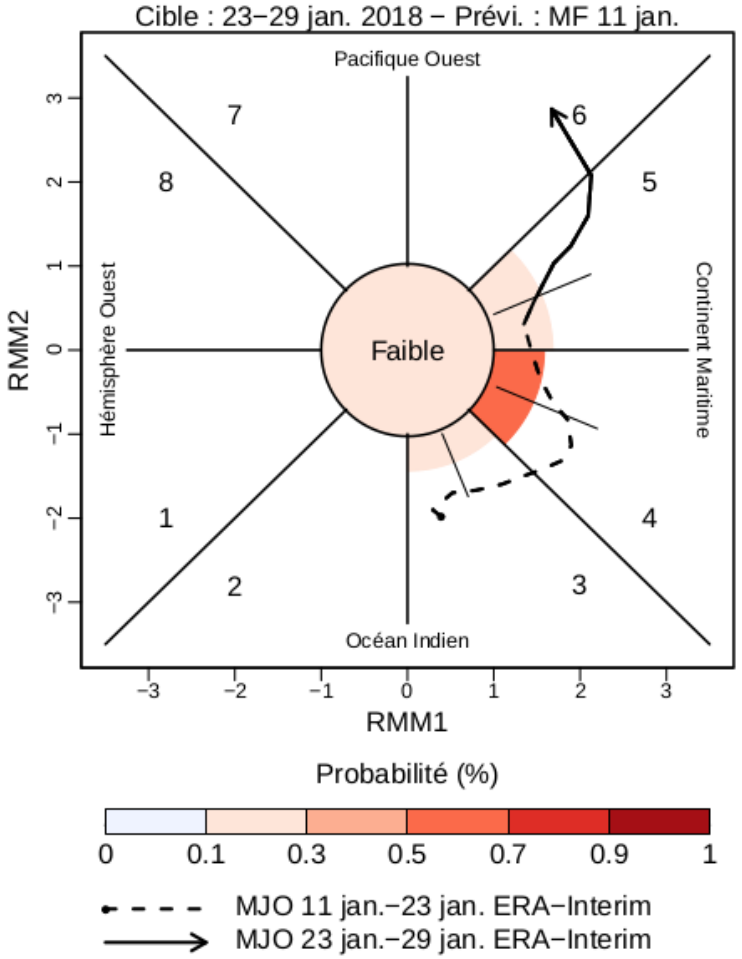
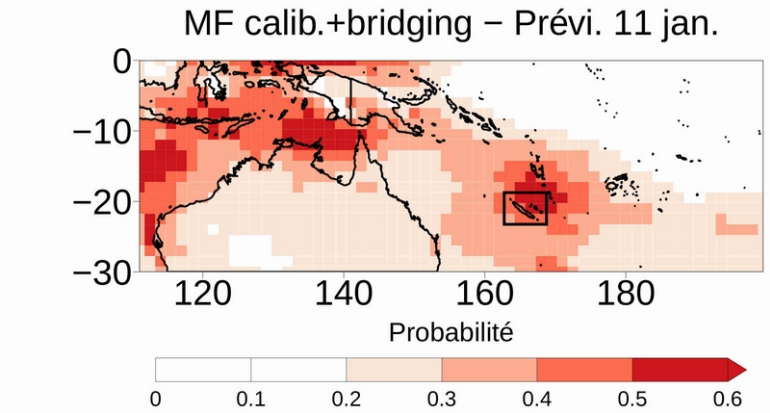
Étude de cas : semaine du 23 au 29 janvier 2018

➢ Prévision du 11 janvier (semaine 2)



◄ Prévision probabiliste de la MJO sur la semaine cible par le système S2S de Météo-France initialisé au 11 janvier



▲ Probabilité d'occurrence du quintile supérieur prévue au 11 janvier par le système S2S Météo-France après approche statistico-dynamique.