Northern Australia Climate Program

Understanding flash droughts and their predictability

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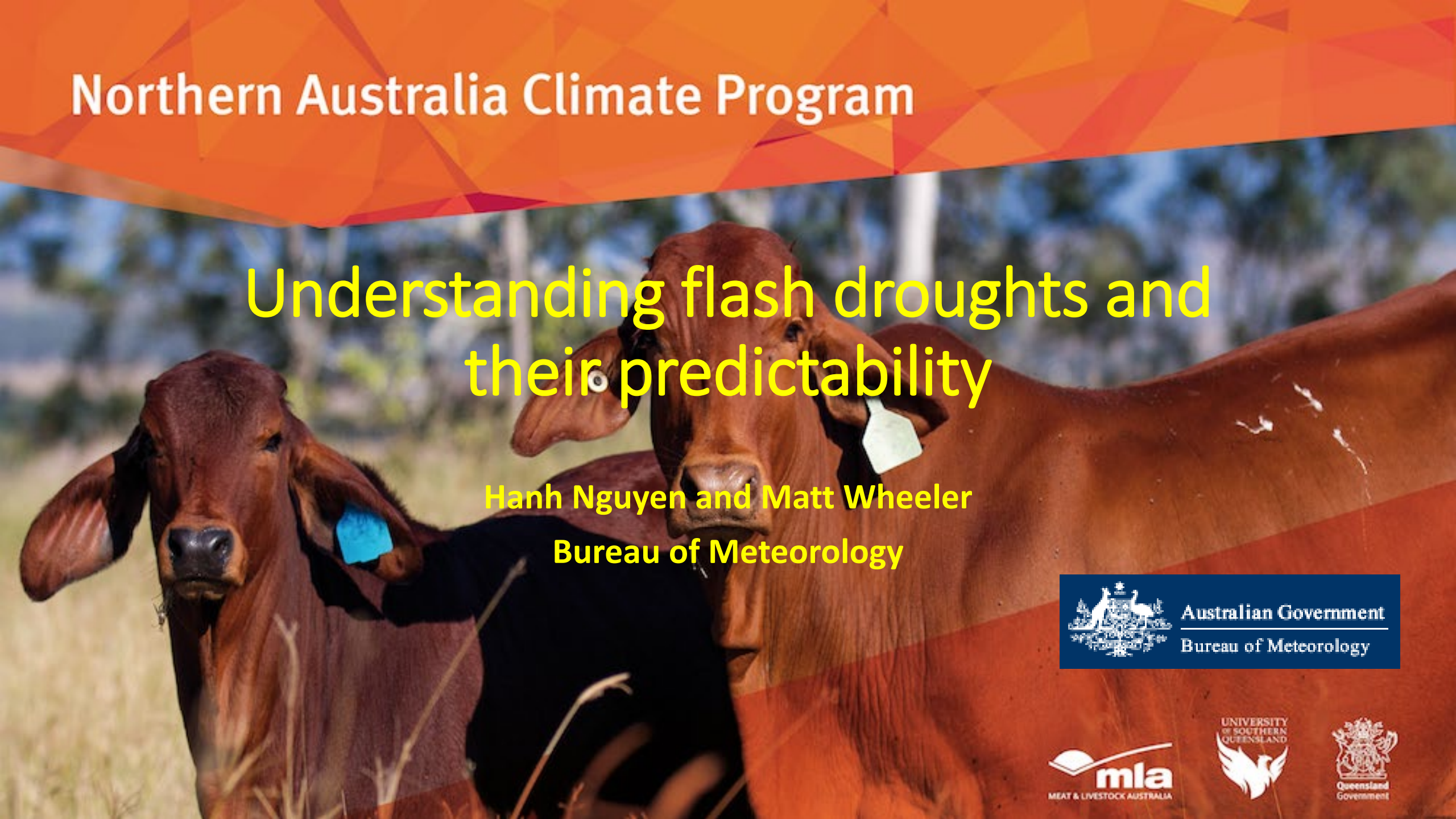
Bureau of Meteorology



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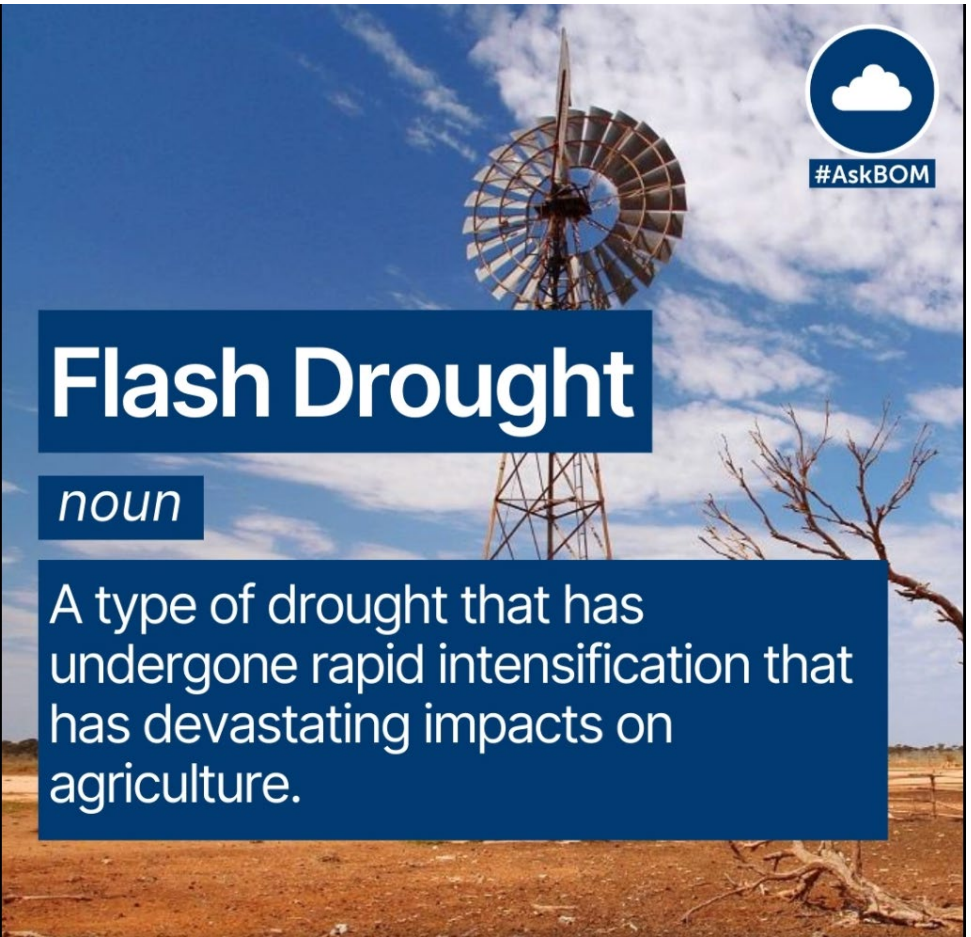
What is flash drought?

- #askBOM



A flash drought is a type of drought that has undergone rapid intensification that has devastating impacts on agriculture.
In contrast with a conventional drought, which is mainly driven by a long deficit of rainfall, flash droughts usually develop quickly and may include abnormally high temperatures, strong winds and/or increased incoming solar radiation that leads to high evaporative demand.
Flash droughts can destroy crops over large areas and impact vegetation growth.

How do we monitor flash drought?

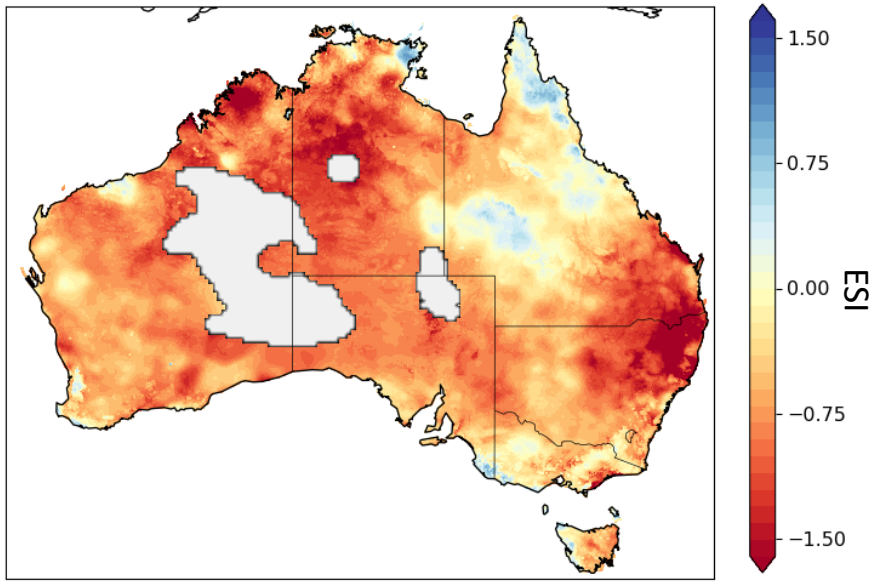
- We use the Evaporative stress index (ESI) which is the standardized ET/PET ratio r_{ET} (ET is actual evapotranspiration; PET is potential evapotranspiration) from the Bureau's AWRA-L water balance model

$$ESI = \frac{r_{ET} - \langle r_{ET} \rangle}{\sigma(r_{ET})}$$

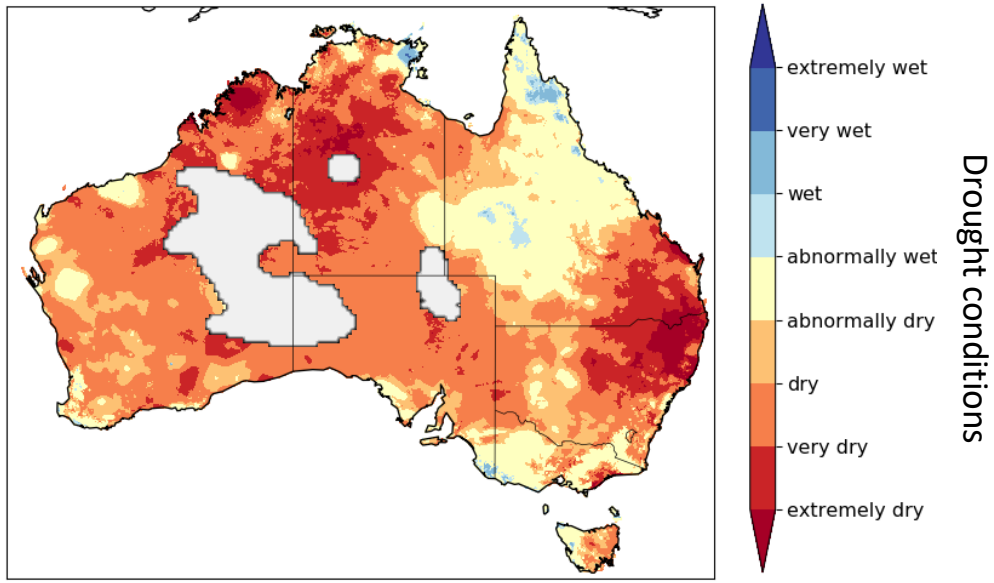
- During flash drought, rapid decreases in the ESI occur due to the combined effect of an increased evaporative demand (PET↑) and decreased availability of soil moisture (ET↓)
- Calculated daily over a 4-week window with the date of a given window corresponding to the last day of that window

How do we monitor flash drought?

The 2019 annual mean ESI



ESI translated into drought conditions



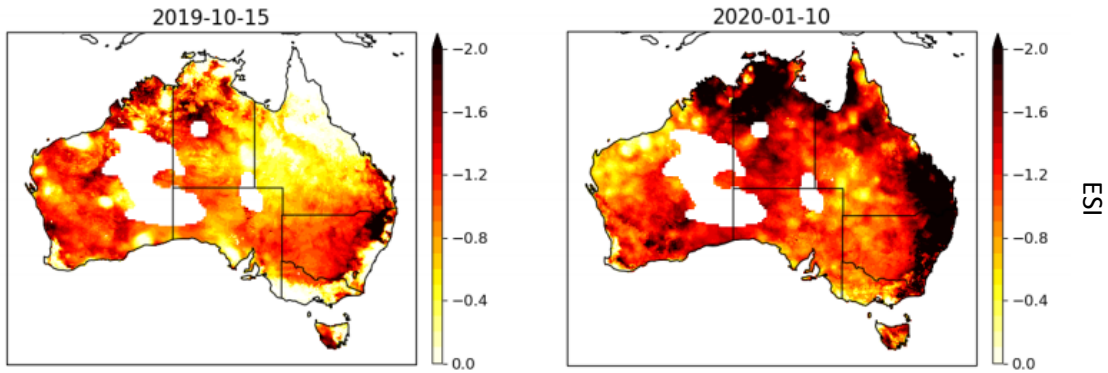
The 2019 flash drought

Highlights and significant events

Developing new tools to track the rapid intensification of agricultural drought

As part of the Northern Australia Climate Project, the Bureau has been working on tools that can help identify and potentially predict the rapid intensification of agricultural droughts. An example of this intensification occurred in eastern Australia during late 2019, when the existing dry conditions rapidly worsened due to a combination of very low rainfall, high temperatures and sometimes stronger winds. The Evaporative Stress Index (ESI), which is based on the ratio between actual and potential evapotranspiration, has been applied and studied in Australia for the first time to capture these aspects of drought that are important for vegetation.

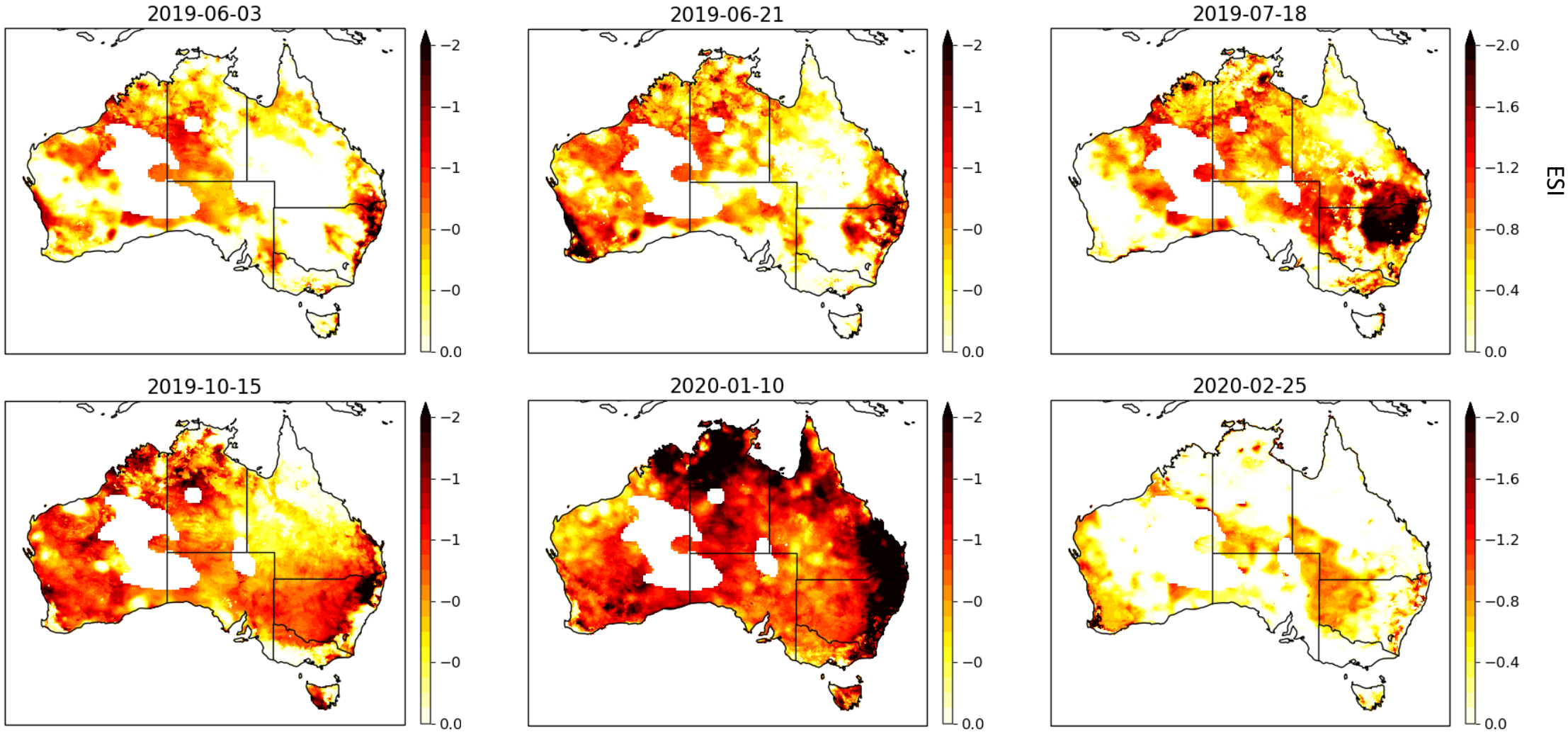
In times of worsening drought, potential evapotranspiration far exceeds the actual evapotranspiration, meaning that rapid and strong decreases in the ESI can be used to indicate a 'flash drought'. Such changes in the ESI were observed over eastern Australia from mid-October 2019 to mid-January 2020. Work is continuing on using the ACCESS-S model to predict these changes in the ESI for valuable input to the Bureau's agricultural customers.



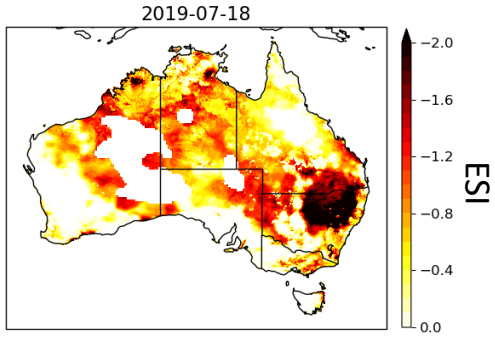
The Evaporative Stress Index (ESI) on 15 October 2019 (left) declined rapidly in eastern Australia to its value on 10 January 2020 (right), indicating a rapid development of agricultural drought conditions.

The 2019 flash drought

Nguyen et al. submitted to WACE



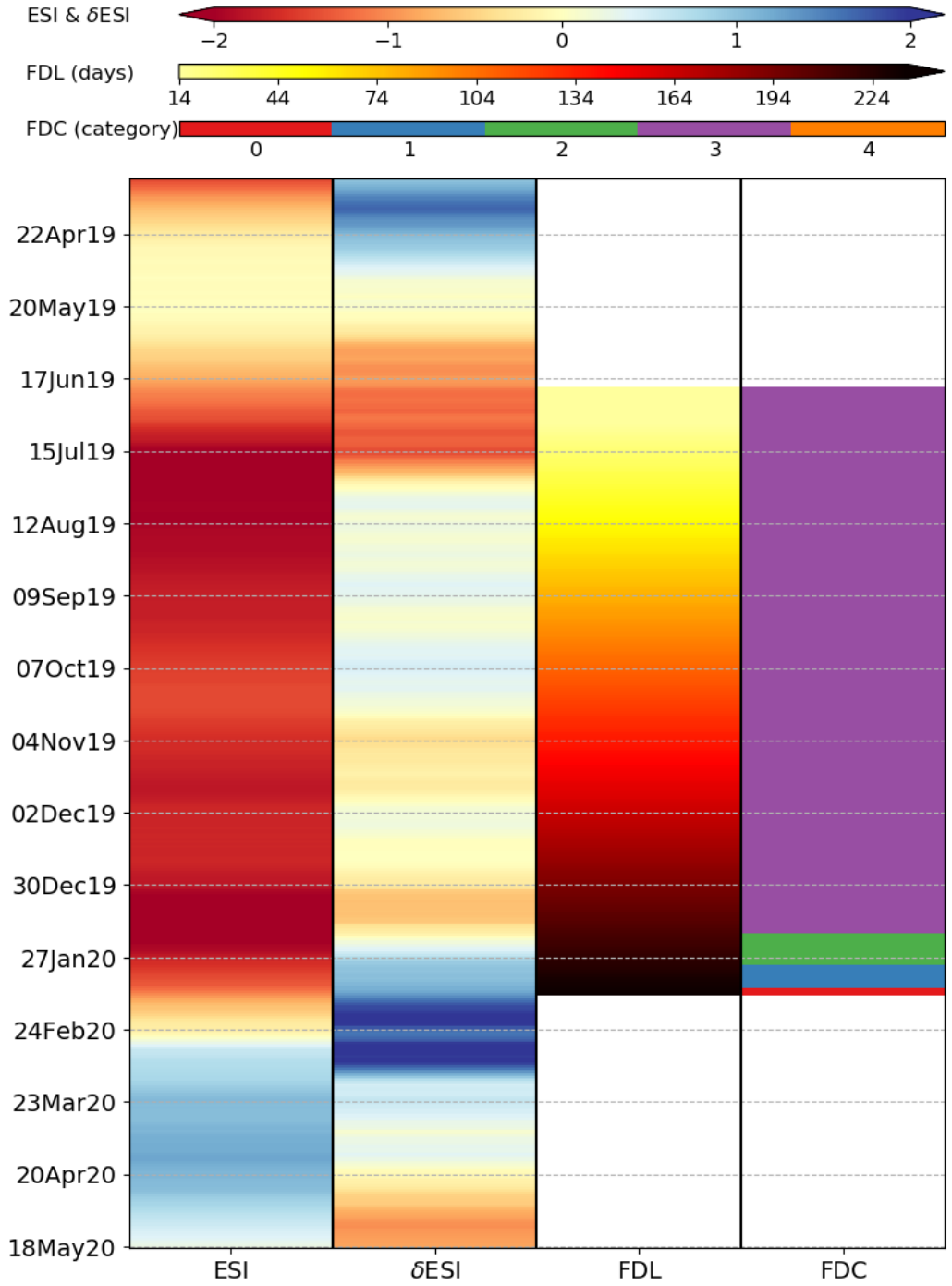
The 2019 flash drought



The ESI change anomalies (**δESI**) over 2-week interval:

$$\delta ESI = \frac{dESI(w_i\_dw_j) - \langle dESI(w_i\_dw_j)\rangle}{\sigma\left(dESI(w_i\_dw_j)\right)}$$

Flash drought characteristics: duration (**FDL**) and severity (**FDC**)



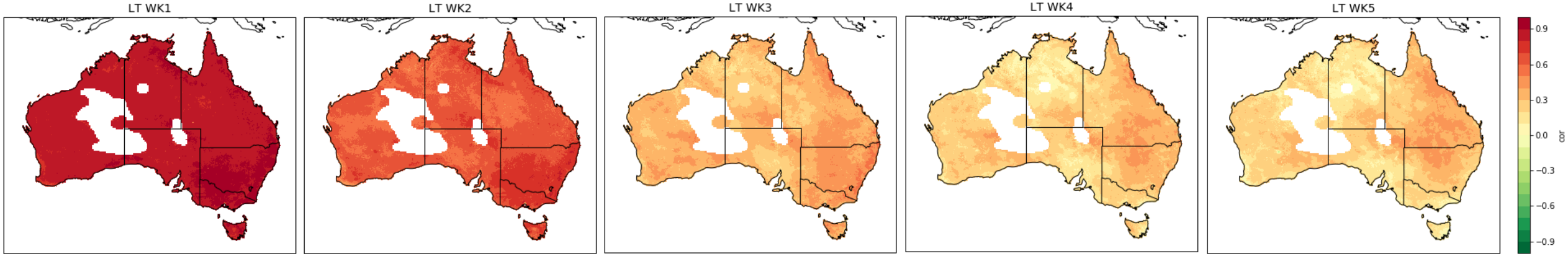
Model skill assessment

- ***ACCESS-S1*** calibrated hindcasts using the quantile-quantile matching method with AWAP to produce high-resolution outputs for Australia
- ***AWRA-Lf*** water balance model forced with ACCESS-S1 seasonal climate forecast (calibrated outputs) to produce high-resolution ensemble forecasting system of soil moisture, evapotranspiration and runoff for Australia
- Resolution: daily 5km over Australia land
- Time period: first day of each month from 1990-2012 for the 11 hindcast ensemble members
- Forecast accuracy:
  - correlation between modelled and observed ESI
  - proportion correct of ESI below median, lower tercile and lower quintile

Using "o" to signify that this is AWRA-L applied to observations

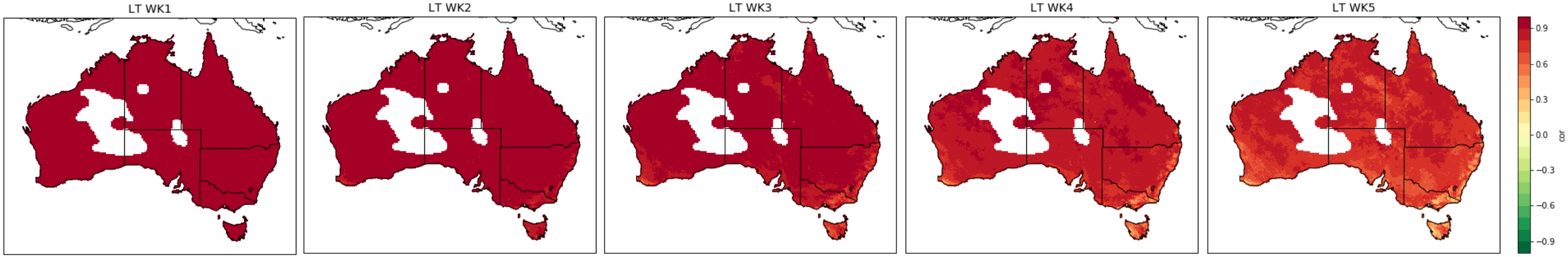
ESI correlation with AWRA-Lo (1/2)

ACCESS-S1

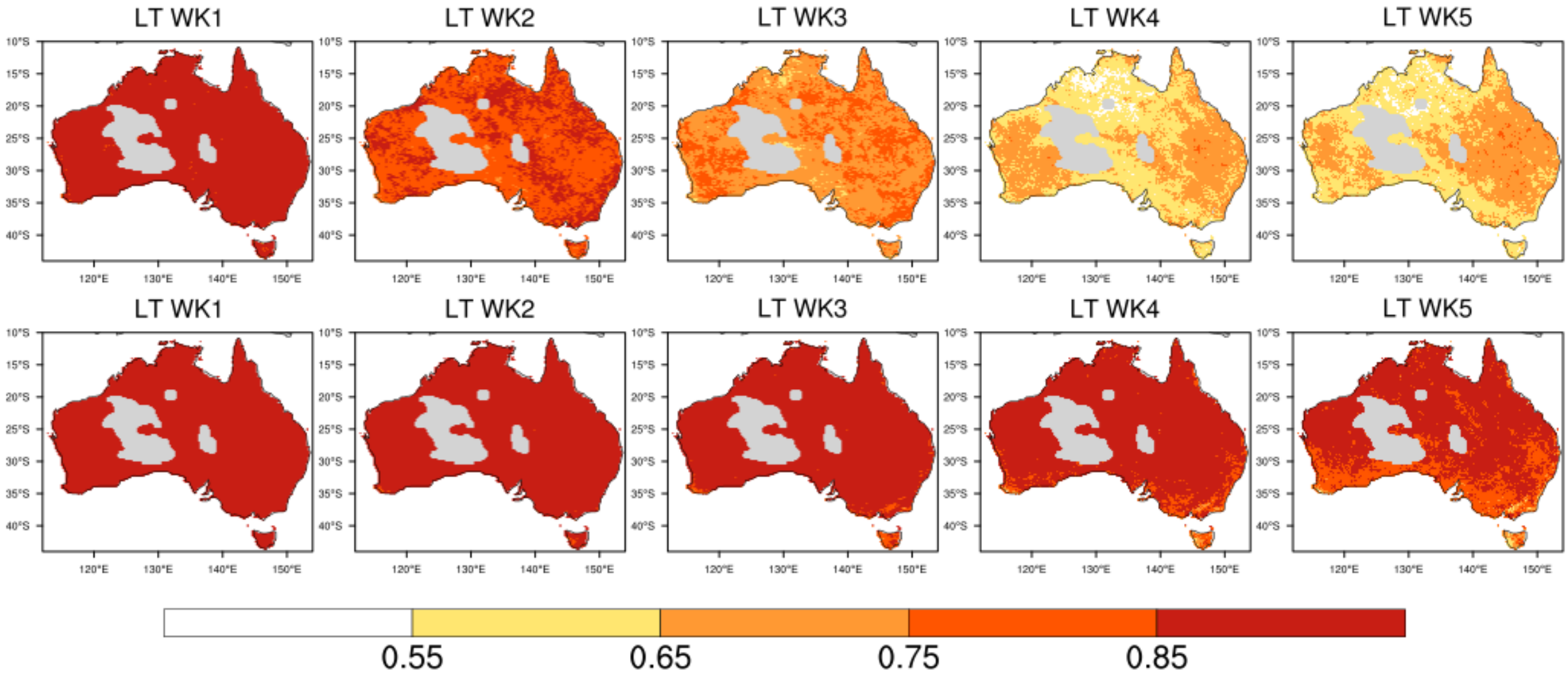


AWRA-Lf

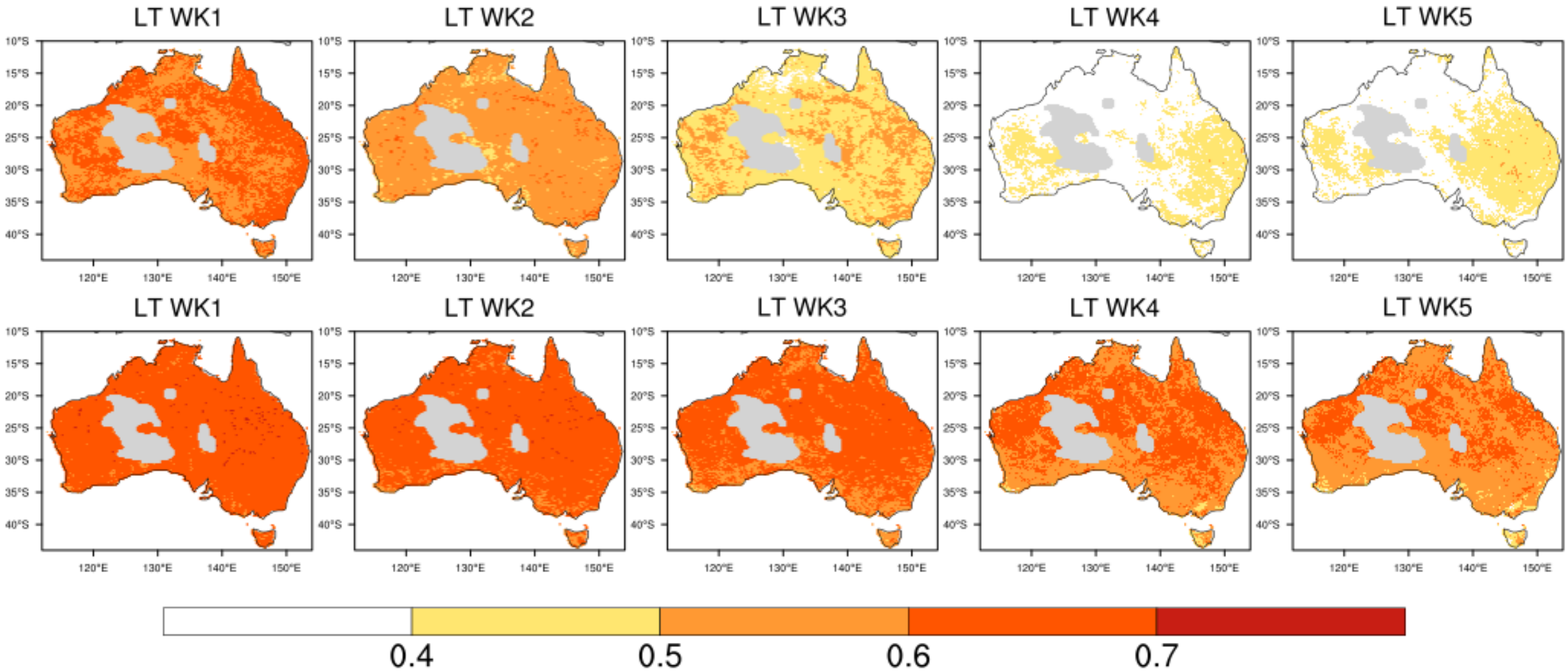
Using "f" to signify that this is AWRA-L applied to ACCESS-S forecasts



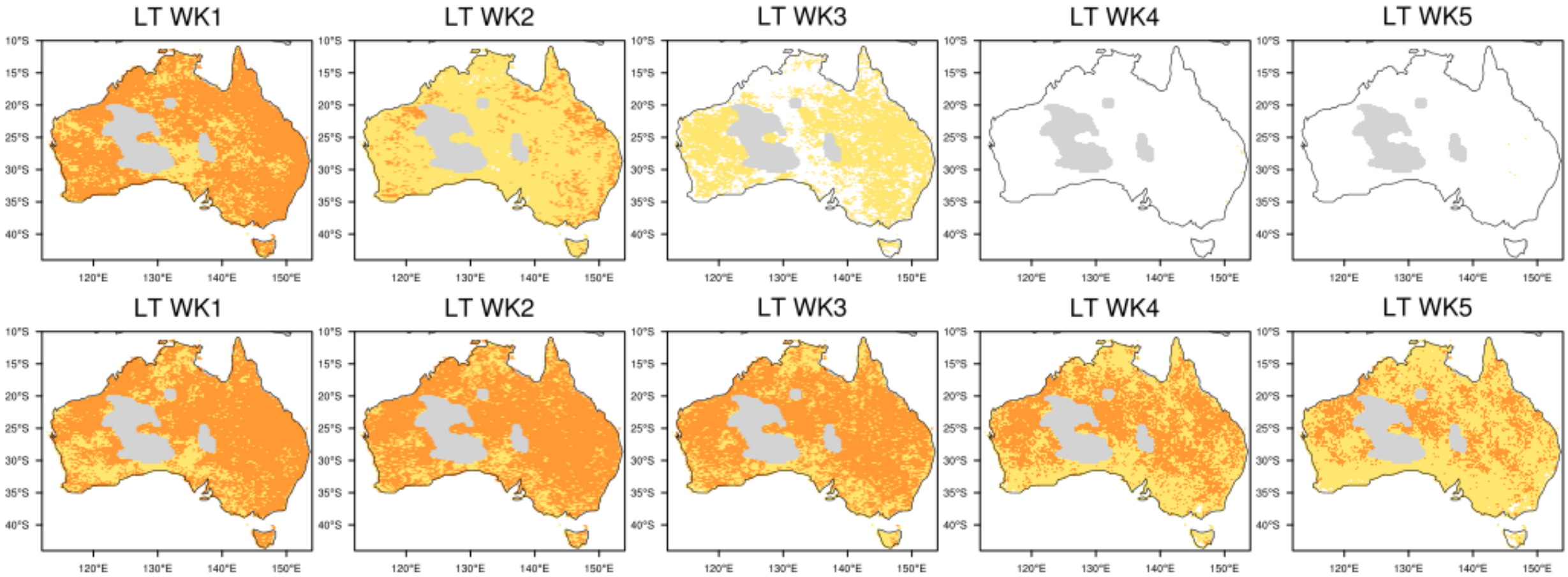
Proportion correct for below median



Proportion correct below lower tercile



Proportion correct for below lower quintile



Summary

- The Evaporative Stress Index (**ESI**) successfully used to monitor flash drought as shown for the 2019 event
- Both forecast methods show strong correlation with observed ESI anomalies but AWRA-Lf (forced by ACCESS-S1) clearly performs better than ACCESS-S1 only
  - ACCESS-S1 forecast skill drops after 3 week leadtime
  - AWRA-Lf remains skilful even at 9 week leadtime
- Better forecast of ET by AWRA-Lf leads to better forecast of the ESI which is expected with expected better representation of local-scale climate and hydrological characteristics
  - Soil moisture is better forecast by AWRA-Lf
- AWRA-Lf also shows strong skill in reproducing ESI extremes (quintile) suggesting it can skilfully forecast flash drought