

Fire weakens land carbon sinks before 1.5°C

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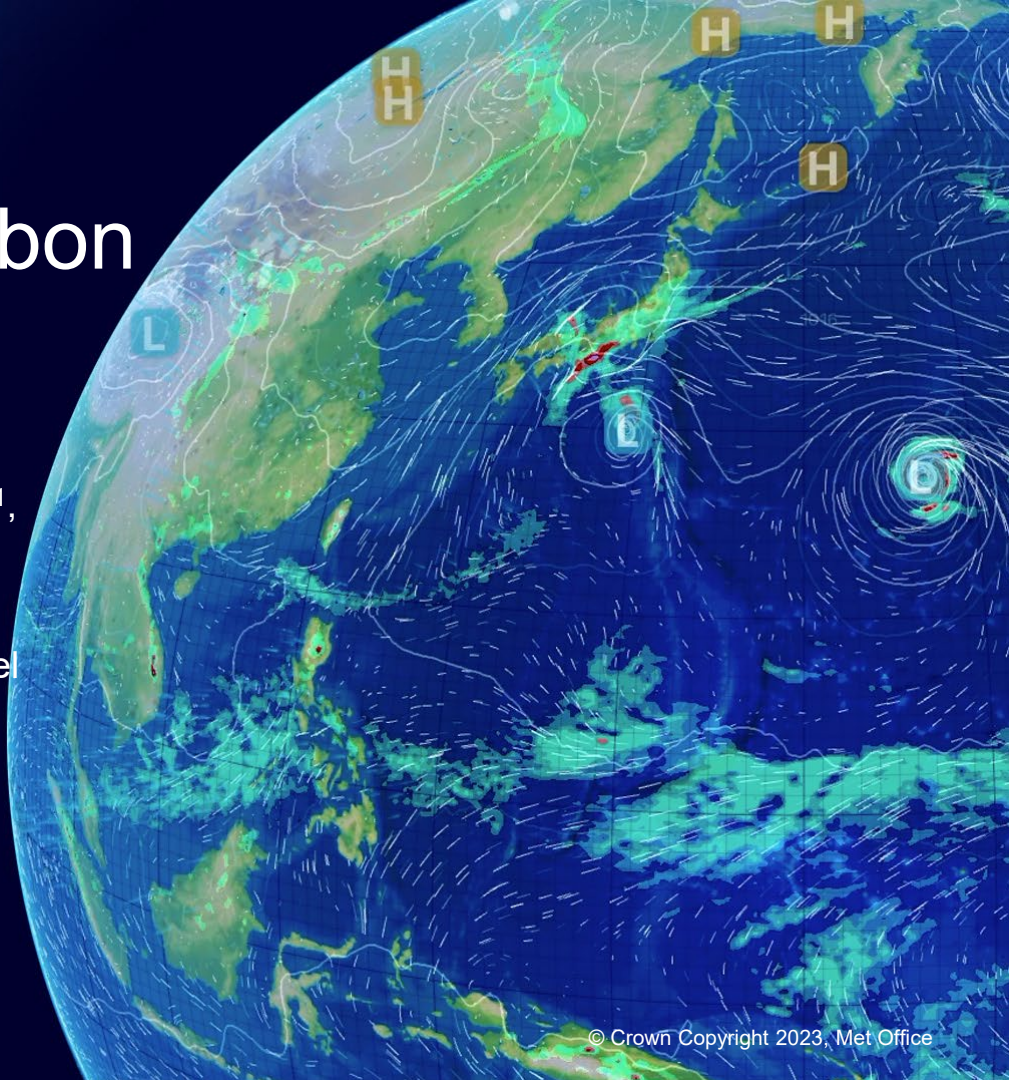
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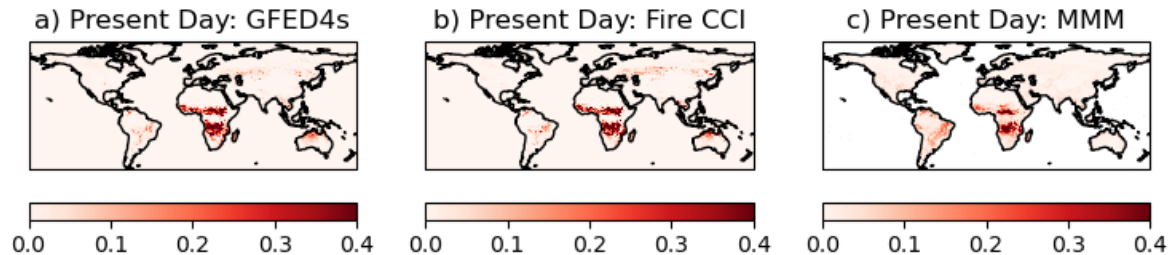


Background

- **Changes to fire regimes** are already occurring due to climate change
- **Fire impacts ecosystems and carbon stores**, and may determine alternate stable states of ecosystems (forest / savanna)
- Fire-vegetation feedbacks may **reduce the capacity of the global sink to store carbon**, as fire regimes change in the future with climate change
- **Many models** used for 1.5°C (CMIP5) **didn't include fire**
- Is 1.5°C still consistent with avoiding **significant ecosystem changes** when considering shifts in fire regimes?



Methods



- **JULES-INFERNO** - nitrogen limitation, dynamic vegetation, fire
- ISIMIP2b – 4 driving climate models (**HadGEM2-ES**, **GFDL-ESM2M**, **IPSL-CM5A-LR**, **MIROC5**)
- **Future scenarios** (RCP2.6), RCP6.0
- Fire at **Global Warming Levels** 1.5°C and 2.0°C (21 year rolling mean)
- Looking for **GWs where impacts become significant**
- Lots of **evaluation** of models for burnt area, tree cover, carbon stores

Results: Change in Burnt Area

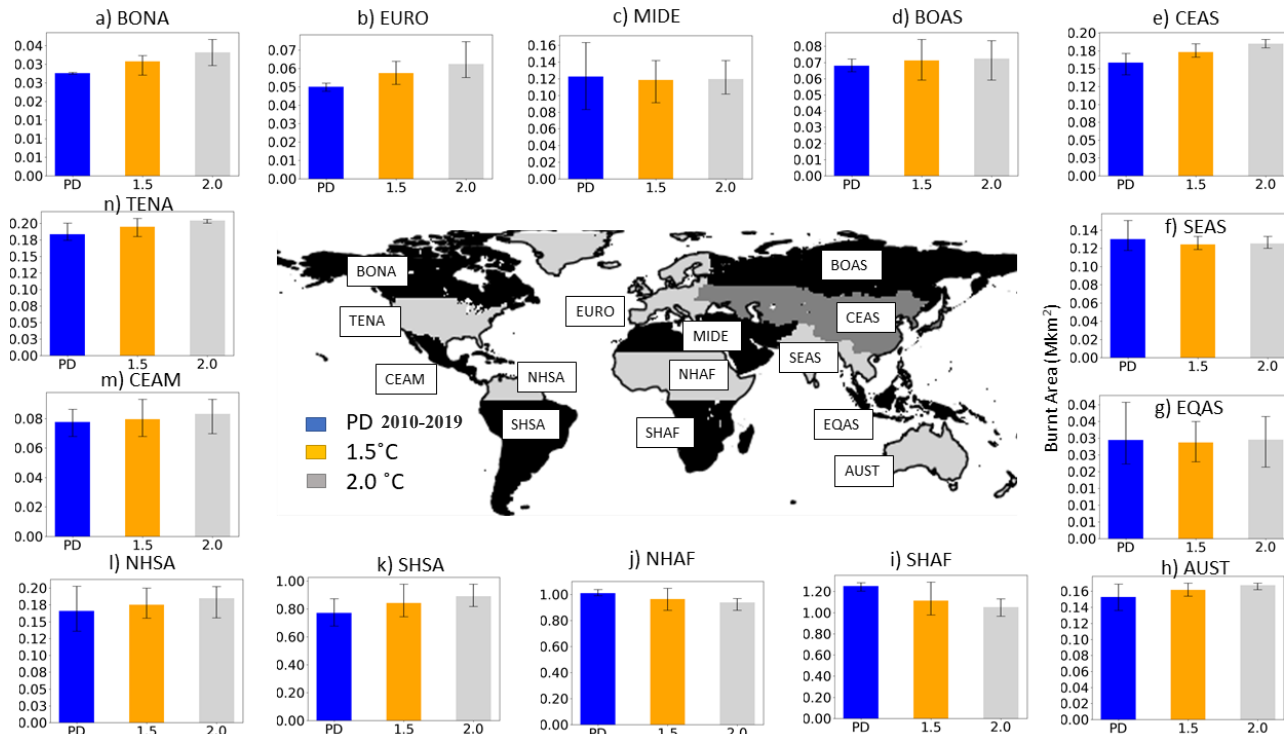
➤ **Burnt area mostly projected to increase from Present Day (PD)**

➤ **Europe: 15% (1.5°C) and 25% (2.0°C) increase**

➤ **Boreal North America 12% (1.5°C) and 20% (2.0°C) increase**

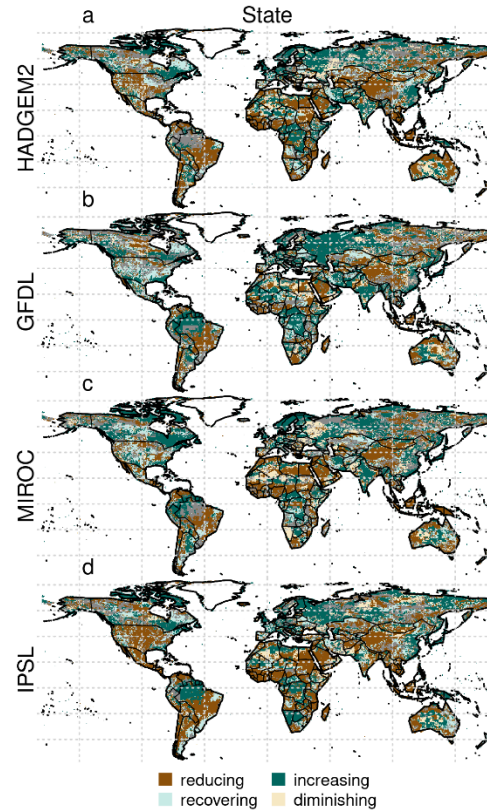
➤ **Decline in Africa**

➤ **High model spread in Equatorial Asia**



Results:

Change in Tree Cover

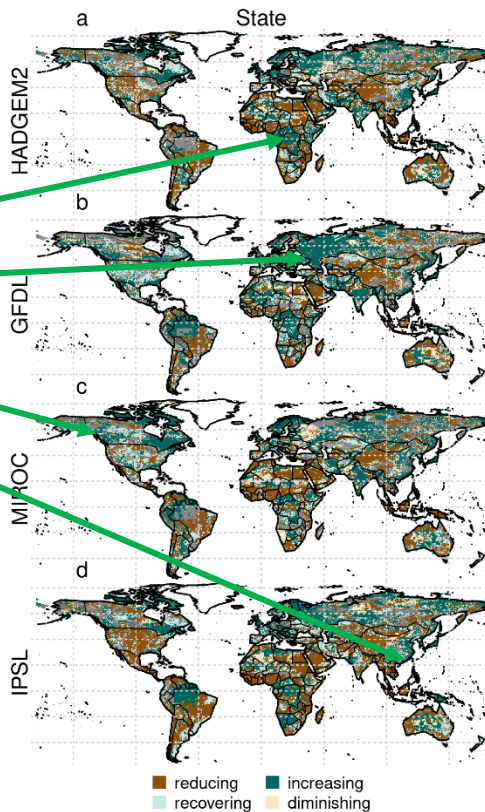


Change in tree cover at 1.5°C above PI

Results:

Change in Tree Cover

Increasing tree cover



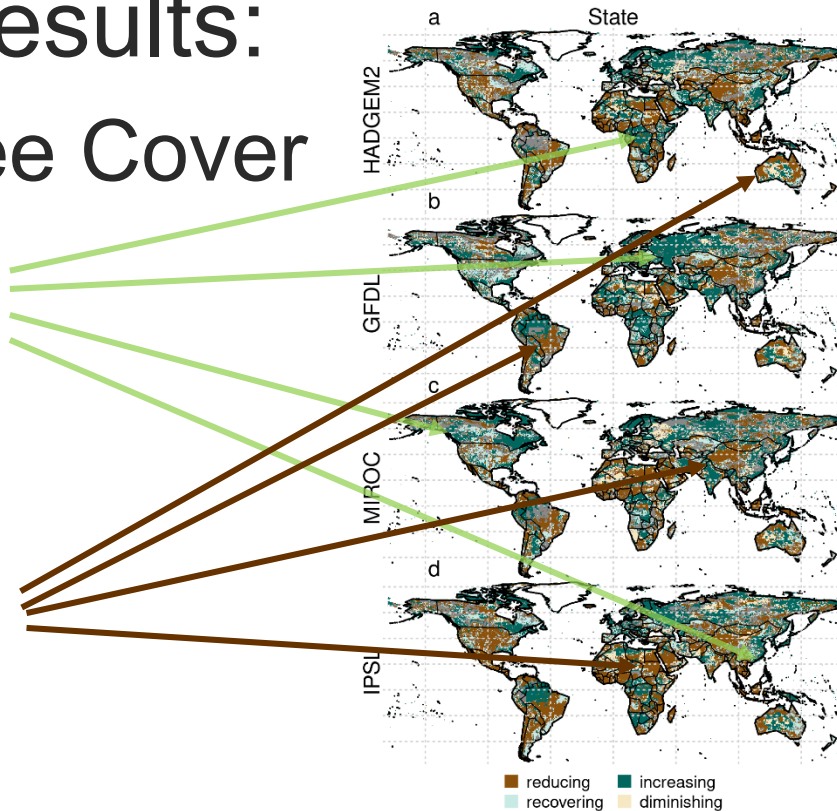
Change in tree cover at 1.5°C above PI

Results:

Change in Tree Cover

Increasing tree cover

Decreasing tree cover

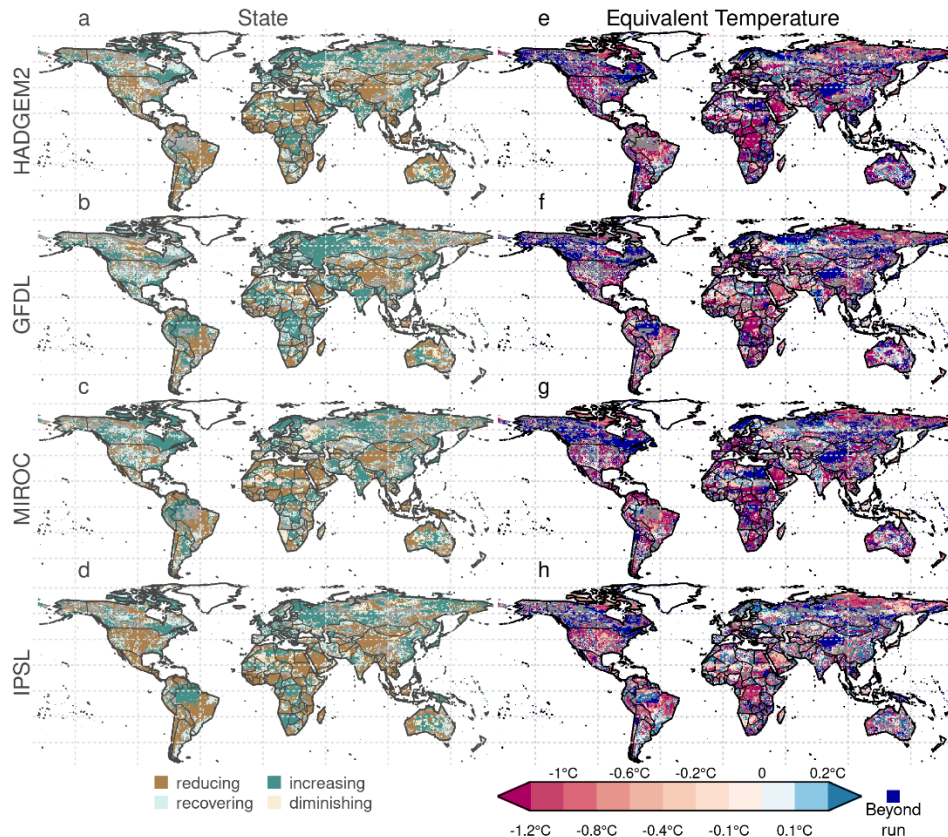


Change in tree cover at 1.5°C above PI

Results:

Change in Tree Cover

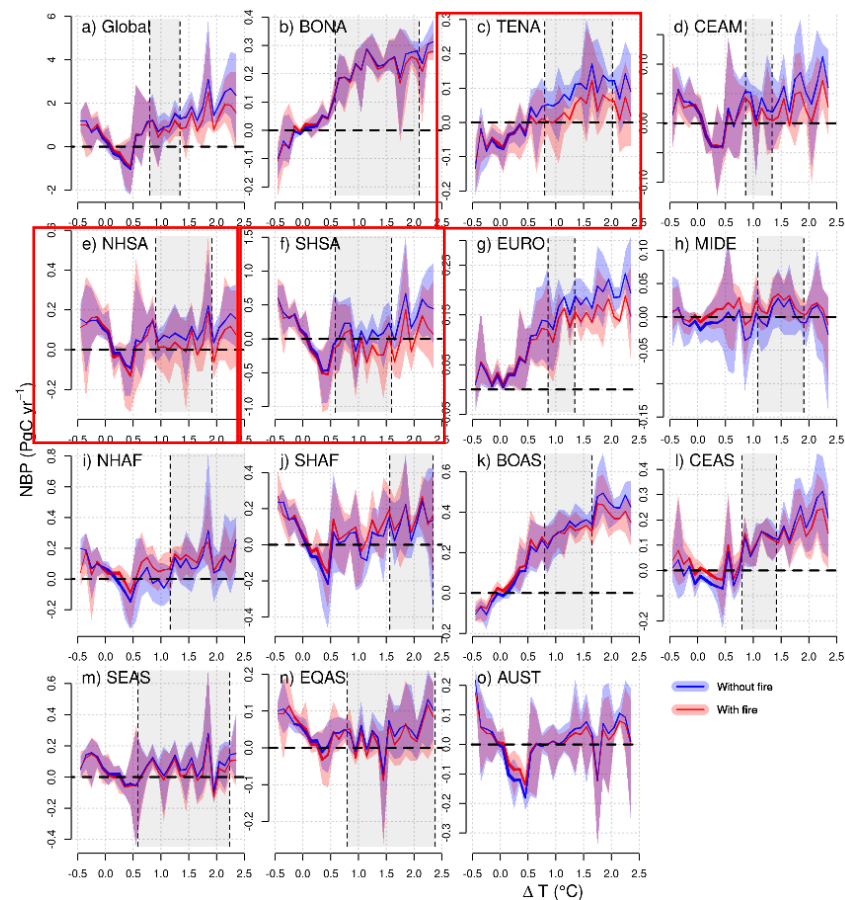
- **'Equivalent impact of change in tree cover'** = the point at which tree cover is at the same level with fire as without fire at 1.5°C above PI
- Equivalent change in tree cover happens at **lower temperatures (red)** with fire
- **Impacts may happen earlier** than we thought



Temperature of equivalent impact

Impact on Net Biome Productivity

- NBP increases globally and in boreal regions with temperature
- NBP mostly decreased with fire (red vs blue)
- Some regions are close to a sink/source threshold
- Fire can shift some regions from a net sink -> net source



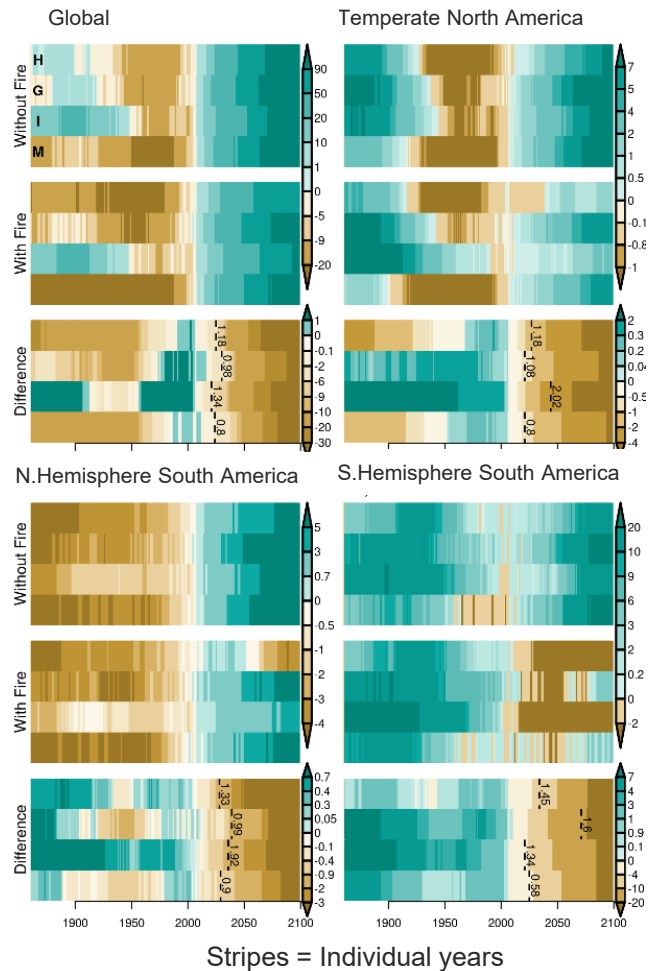
NBP with and without fire by temperature

Results:

Impact on Net Biome Productivity

- More shifts from **sink to source** (brown stripes) 'with fire'
- Fire has a **negative impact by the end of the century**, offsetting CO₂ fertilisation
- We find that the global warming level at which **fire significantly impacts global carbon storage is 1.07°C** (0.8-1.34°C) above pre-industrial (with fire vs without fire, anomaly from PD, Wilcoxon signed-rank test)

Rows = GCMs



Stripes = Individual years

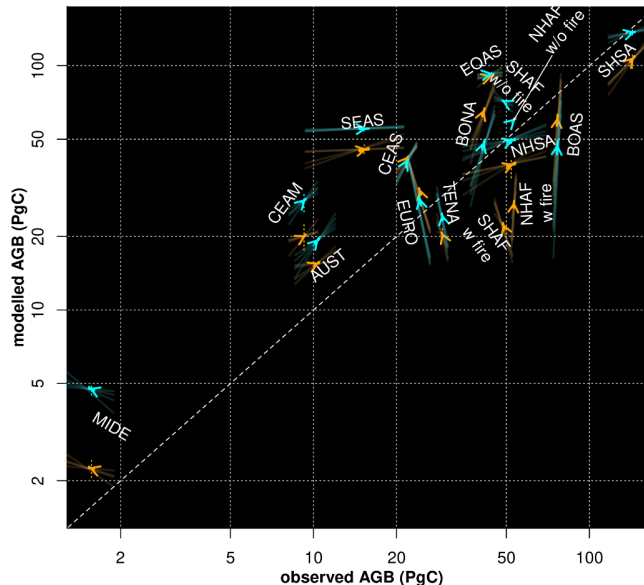
Conclusion

- **Impacts happen earlier** when we account for fire
- Fire **significantly impacts global carbon storage** at 1.07°C above PI
- Therefore, regions which were previously projected to continue as a net sink of carbon into the future may be closer to a threshold than previously understood, and those **impacts could be starting now**.
- We estimate the reduction in the **remaining carbon budget** due to fire is 15 GtCO₂ for limiting temperature rise to 1.3°C, **25 GtCO₂ for 1.5°C**, and 64 GtCO₂ for 2.0°C compared to IPCC AR6

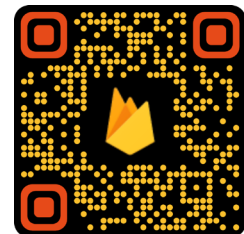


Criteria tested to ensure framework can find how **considering fire** affects significant impacts:

- Capture's **spatial patterns and trends** in:
 - Burnt Area
 - Tree cover
 - Vegetation carbon
- **Without fire simulation performs as well as with fire** for present day spatial patterns in tree cover and vegetation carbon
- **With fire outperforms** without fire in changes/trends in tree cover and vegetation carbon



	GFDL	HADG EM	IPSL	MIRO C
BONA	96.61	99.94	99.9	96.74
TENA	92.4	99.53	95.54	99.1
CEAM	82.98	77.46	92.16	71.47
NHSA	81.59	89.77	87.31	100
SHSA	69.33	64.33	55.18	65.05
EURO	50.3	43.15	44.42	42.55
MIDE	98.84	94.94	96.78	97.15
NHAF	49.11	27.44	41.65	36.4
SHAF	97.13	97.31	97.23	97.15
BOAS	89.4	92.02	94.92	92.13
CEAS	40.2	33.48	39.64	42.72
SEAS	71.68	71.64	71.37	65.78
EQAS	83.84	87.16	86.45	87.44
AUST	65.46	72.66	62.94	67.89



See qr code for more detail