CSIRO Decadal Climate Forecasting Project

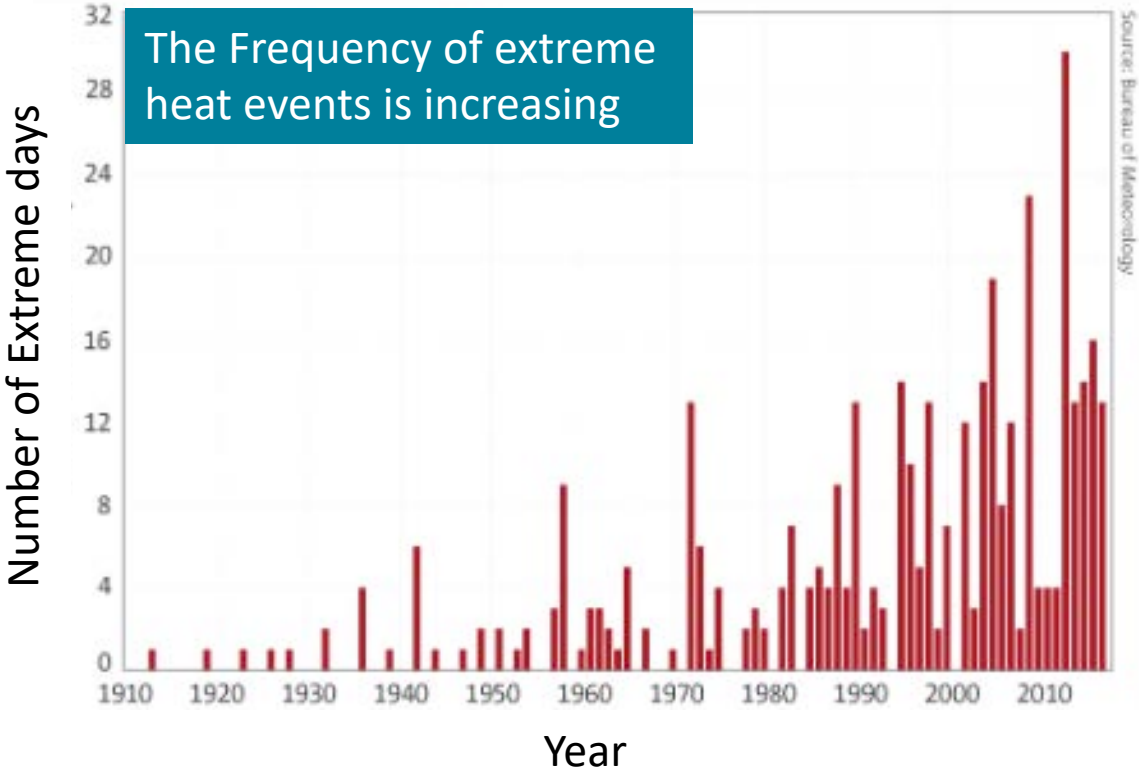
Richard Matear, Project Leader
with important contributions from the Decadal Climate Forecasting Team

Climate Science Centre
O&A Business Unit
OCEANS AND ATMOSPHERE
www.csiro.au

CLIMATE ANALYSIS FORECAST ENSEMBLE system

Australian Climate Trends

- **State of the Climate 2018**



- Climate is changing with more and stronger extremes
- Applies to rainfall, floods, marine heatwaves

Need to better manage climate variability and extremes: Year of Extremes

The Guardian

Floods, fire and drought: Australia, a country in the grip of extreme weather bingo

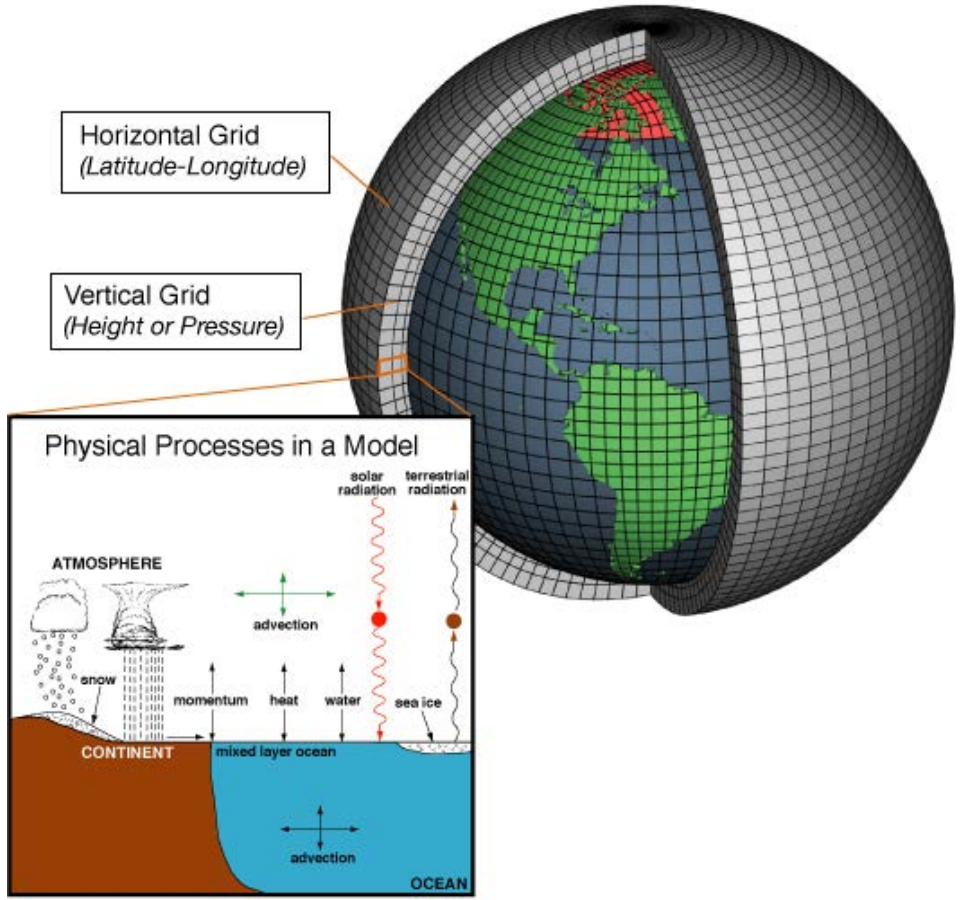
Amid record temperatures, severe flooding and devastation of wilderness, the political message from the government is business as usual

▲ Residents wade through floodwaters in the suburb of Hermit Park in Townsville this
Peled/EPA

Our approach in the CSIRO Decadal Climate Forecasting Project

Global Climate Model (GCM)

- work horse of project's climate research activities
- **Includes Atmosphere, Land, Ocean with biogeochemistry and sea ice**
- **Incorporates many processes – complex system**
- Resolution typically 100 km



Project's Mission

Improve multi-year to decadal climate forecasts

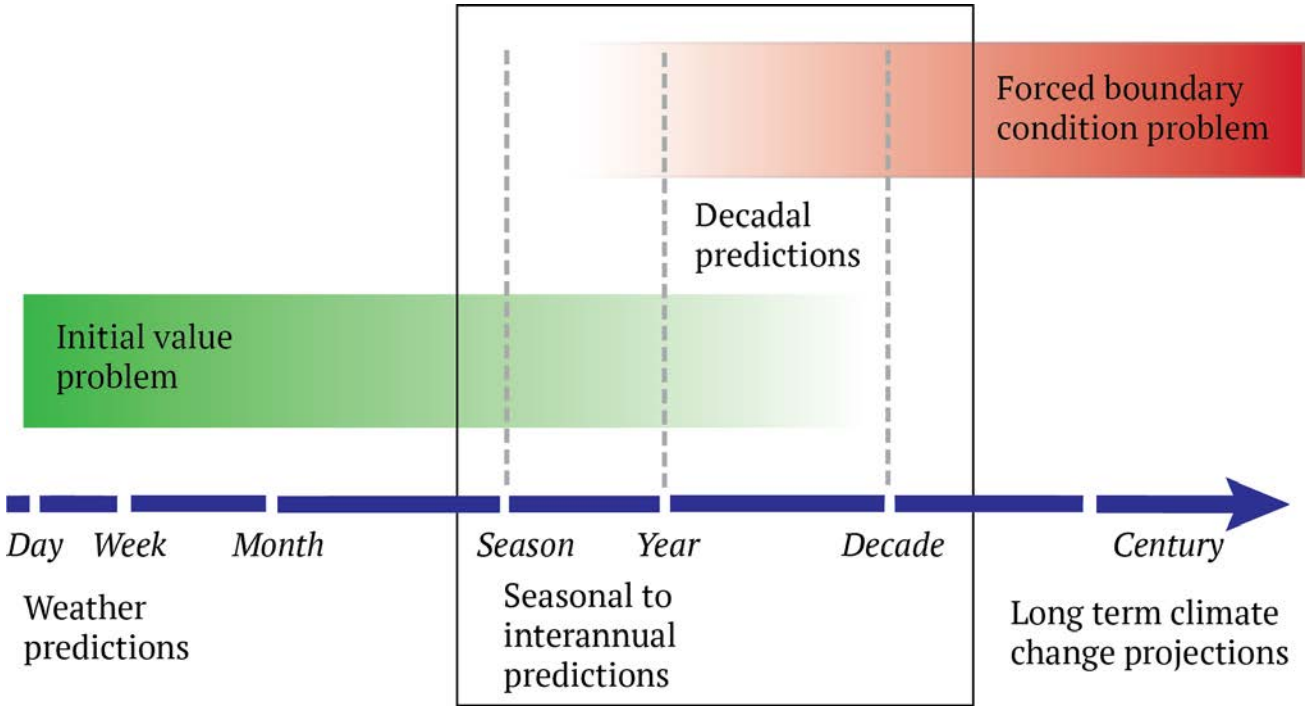
- Advance fundamental climate research into: where does the predictability of the climate system reside, the processes that give rise to that predictability, and the critical observations that will help us to realise the potential climate predictability
- Apply state-of-art ensemble data assimilation to determine the climate state
- Closely integrating climate processes with the forecasting effort in the development of the climate perturbations used in the ensemble forecasts

Demonstrate the utility of climate forecasts

- Closely integrating verification and applications with forecasting effort (targeted evaluation linked with the application)
- Process understanding and process verification

Climate Modelling

- Projections: Radiative Forcing Problem largely independent of initial climate state



- Decadal Forecasting: Initial value problem where we need to determine the initial climate state

Initial Climate State: Ensemble Data Assimilation of the observations

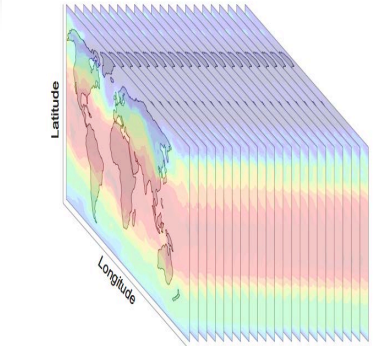
- Ocean observations are critical
- rapid increase in ocean observations
- upper ocean state sets the behaviour of the climate on annual and longer time scales

- 96 member Ensemble Kalman Filter for assimilating ocean, atmosphere, sea ice, and ocean colour observations

Space-based observations

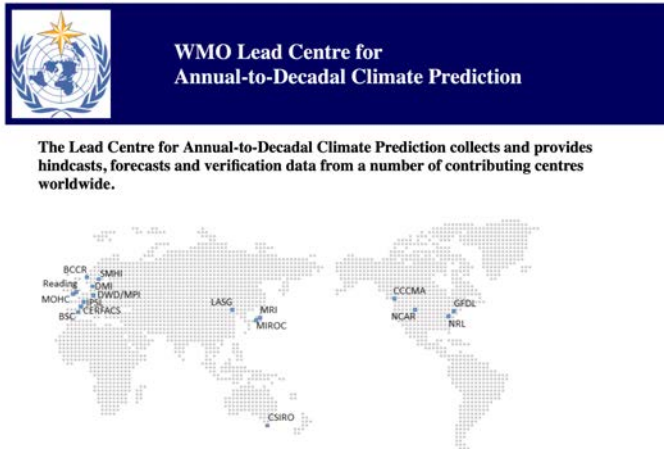
In sea observations

15M profiles since 1960



CAFE60: Annual to Decadal Forecasting

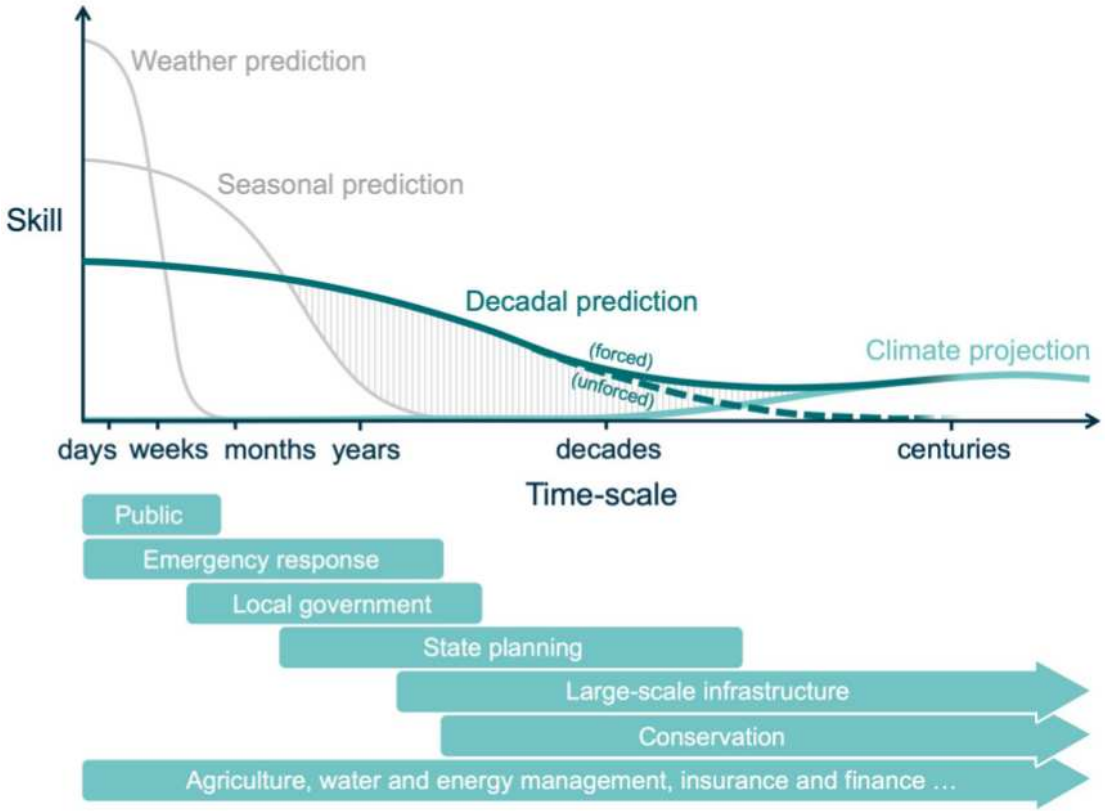
- climate reanalysis, 1960 -2019, ensemble of 96 realisations (Dec 2019)
  - Monthly data assimilation cycle
- Ensemble Decadal Climate forecasts (10-members, 1960 – 2019)
  - Contribution WMO Centre for Annual to Decadal Climate Prediction
- Large Ensemble of Decadal Climate Forecasts (96-member, 2010 -2020)
  [Australian Large Compute Grant]



https://hadleyserver.metoffice.gov.uk/wmolc/

Applications – James Risbey

Weather and Climate forecast skill

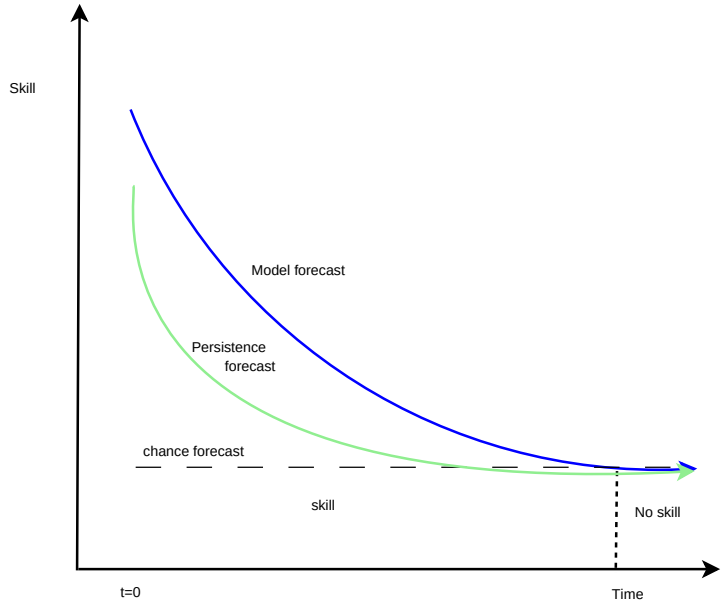


What makes a climate forecast useful?

- Forecast something you care about
  - drought, heat, flood
- Do it better than other methods
  - better than relying on the past
  - better than chance
  - better than not using it
- Change the decisions you make
  - weather : tactical decisions
  - climate : strategic decisions
- Provide more reliability for what you do
  - minimize impacts in bad years
  - capitalize on good years

Forecast ‘skill’ and beyond skill

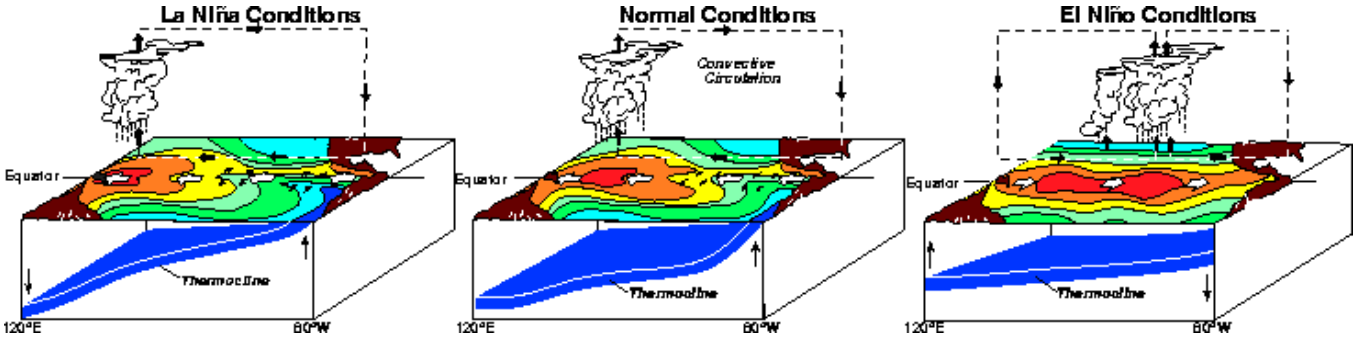
- Forecast skill measured relative to a reference forecast
  - eventually it runs out
  - no longer tracking the target
  - but physics/dynamics still faithful to target
    - capture target statistics, not sequence in time



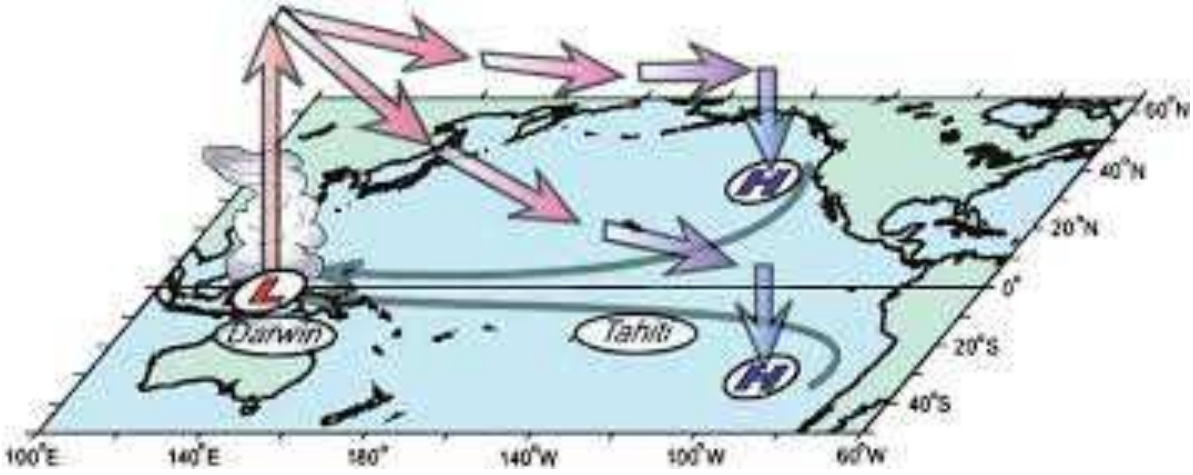
Why are climate forecasts skillful at all?

- weather forecasts lose all skill beyond 2 weeks
- that is because the specific locations of highs and lows are not predictable after that
- if you don't know where the highs and lows are, then you don't know the weather
- climate forecasts don't try to predict the locations of specific highs and lows
- there are slower processes in the climate system than weather systems

Slow processes are in the ocean



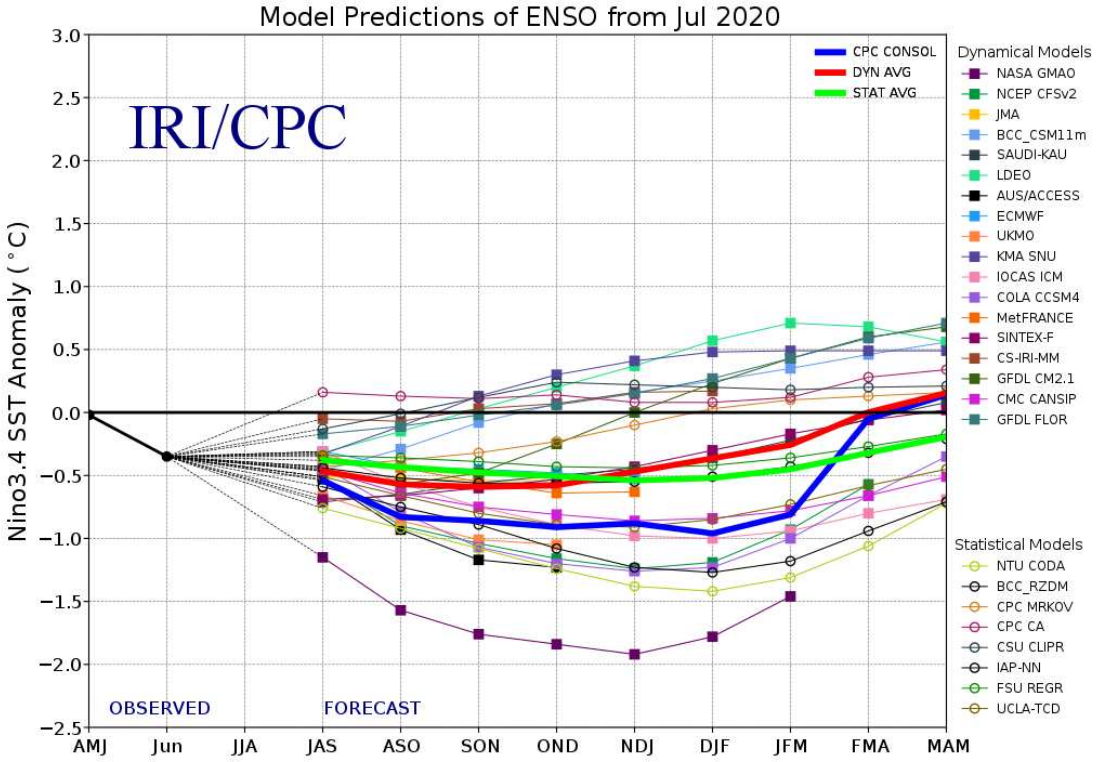
Teleconnections to get signal from ocean to land



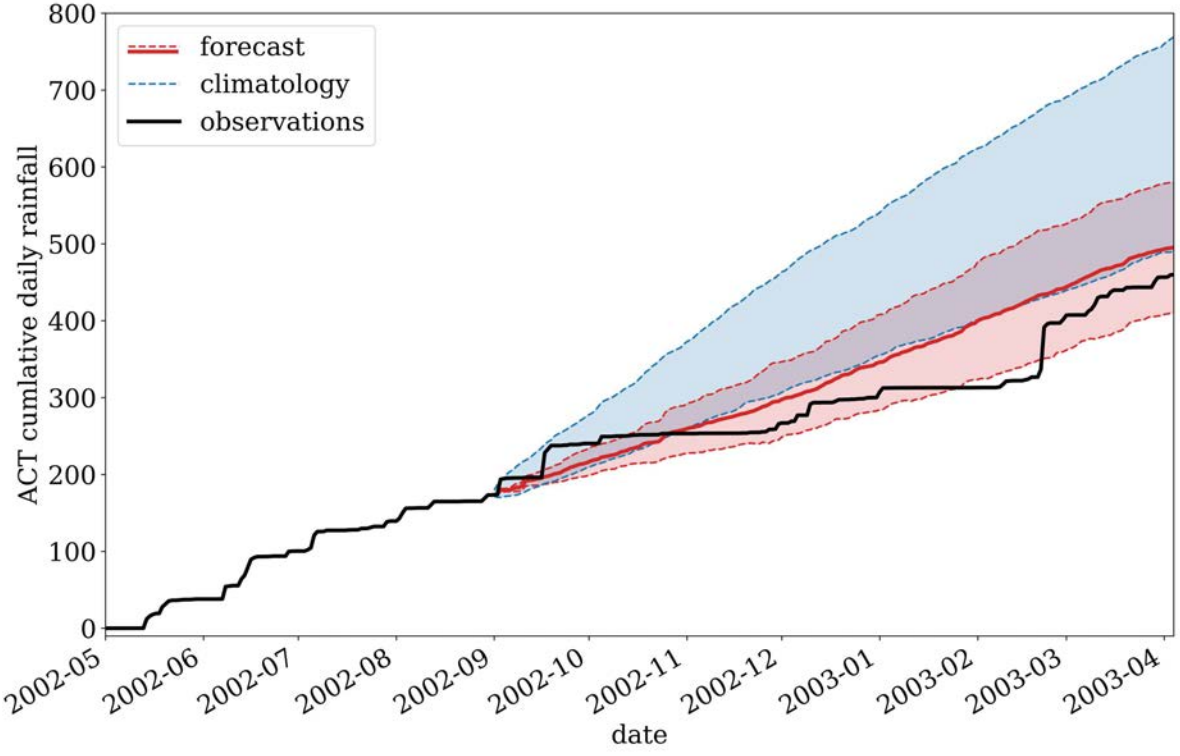
What is forecast in a climate forecast?

1. the state of ‘slow’ processes
   - e.g. ENSO $\rightarrow$ El Niño or La Niña
2. shifts in the odds of things on land
   - e.g. rainfall $\rightarrow$ wetter/drier years
3. knowledge about ‘tail’ events
   - e.g. drought $\rightarrow$ narrow uncertainty on chances of drought in coming year(s)

The state of slow process: ENSO

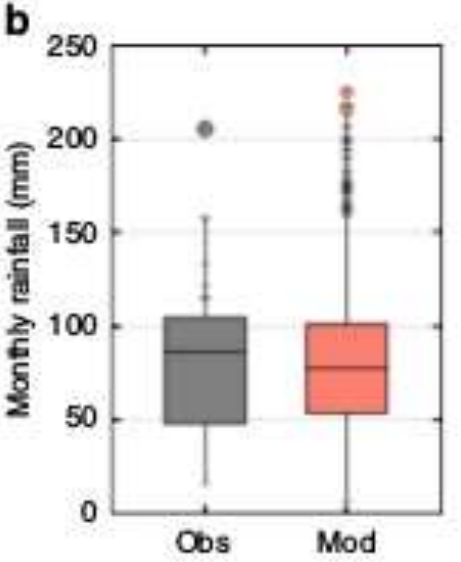


Changes in the odds: cumulative rainfall

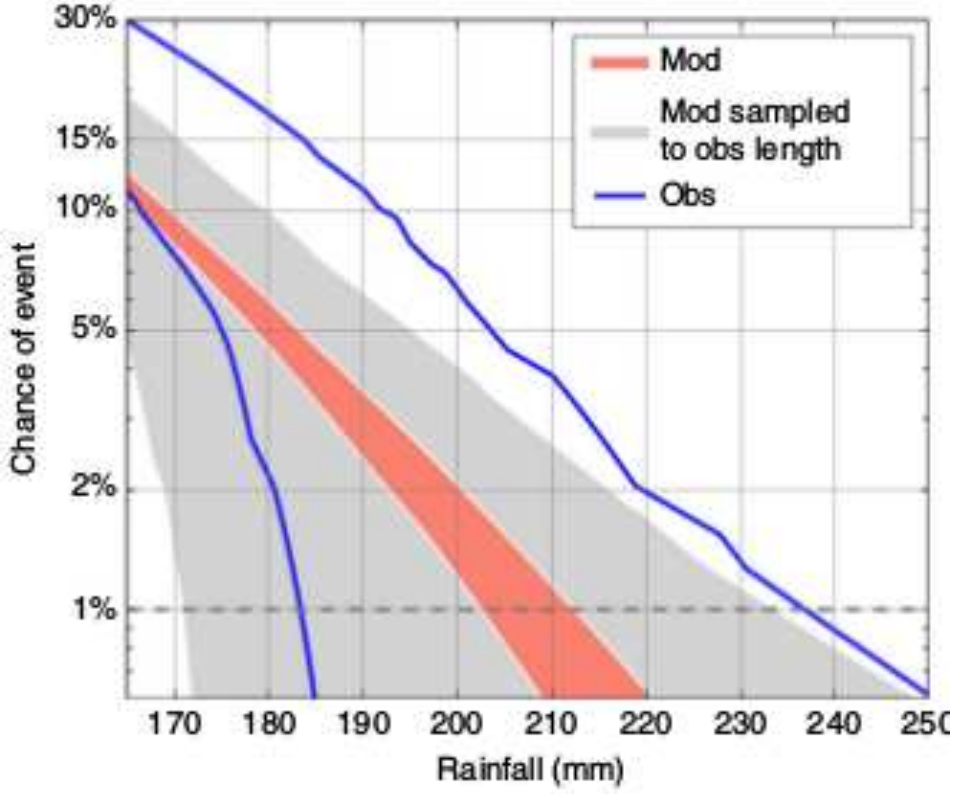


Filling out the tail: extreme rain events

- SE England monthly rain totals
- 40 January's (observations) vs 22,000 January's (model)



Updating and narrowing tail odds



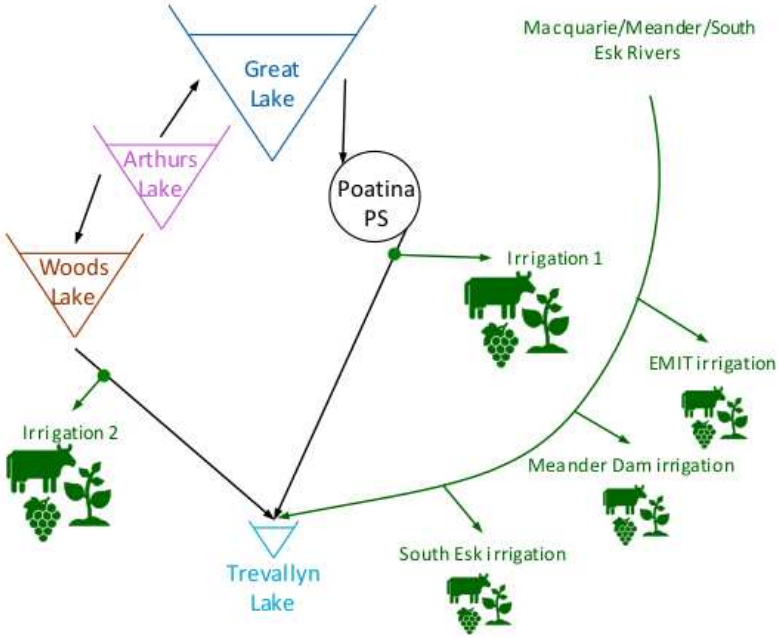
Stakeholder engagement & Partnerships

- Because successful use of climate forecasts requires dedicated engagement
- NESP ESCC supported case study — TasLab
  - Broad stakeholder engagement across Tasmania, including water, energy, agriculture, fisheries, emergency response, Antarctic operations
  - Goal to understand how multiyear climate information impacts operations and how used
  - Provision of tailored forecasts
- Formation of climate consortium

HydroTasmania

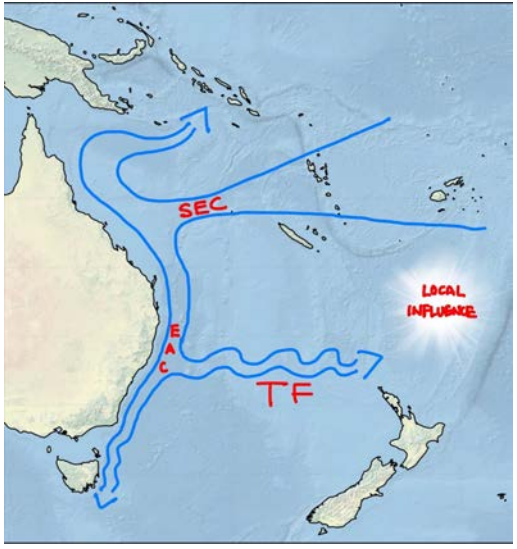
HydroTasmania

- multiyear planning decisions utilize Great Lake
  - buffer for dry years
  - increase profits in wet years (run when price high)



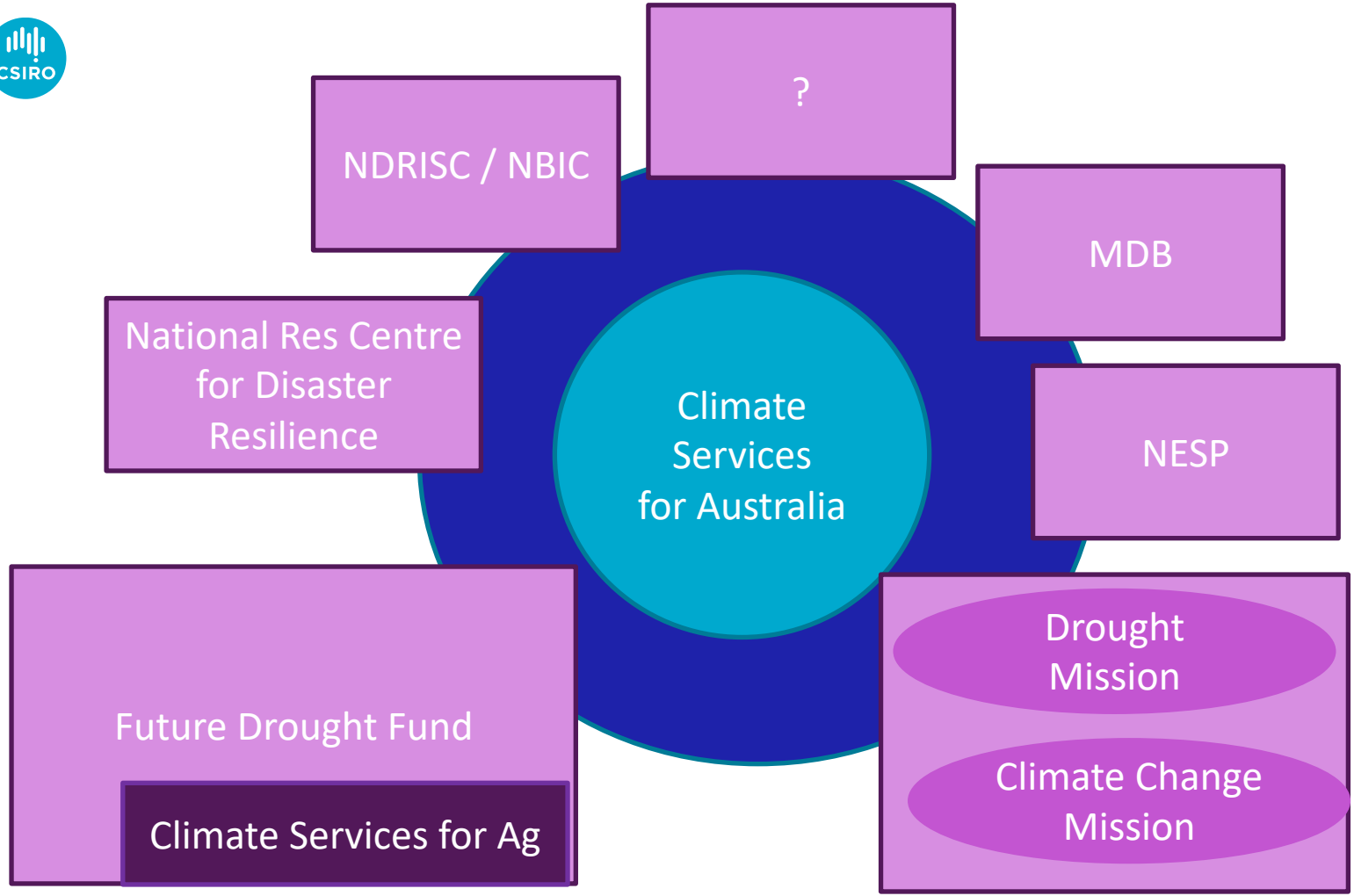
Fisheries

- FRDC funded with AFMA and the industry as clients and Pacific nations as stakeholders
- ocean variability influences the distribution and abundance of major target species
- test multi-year forecasts to extend the prediction horizon from months to 1-2 years

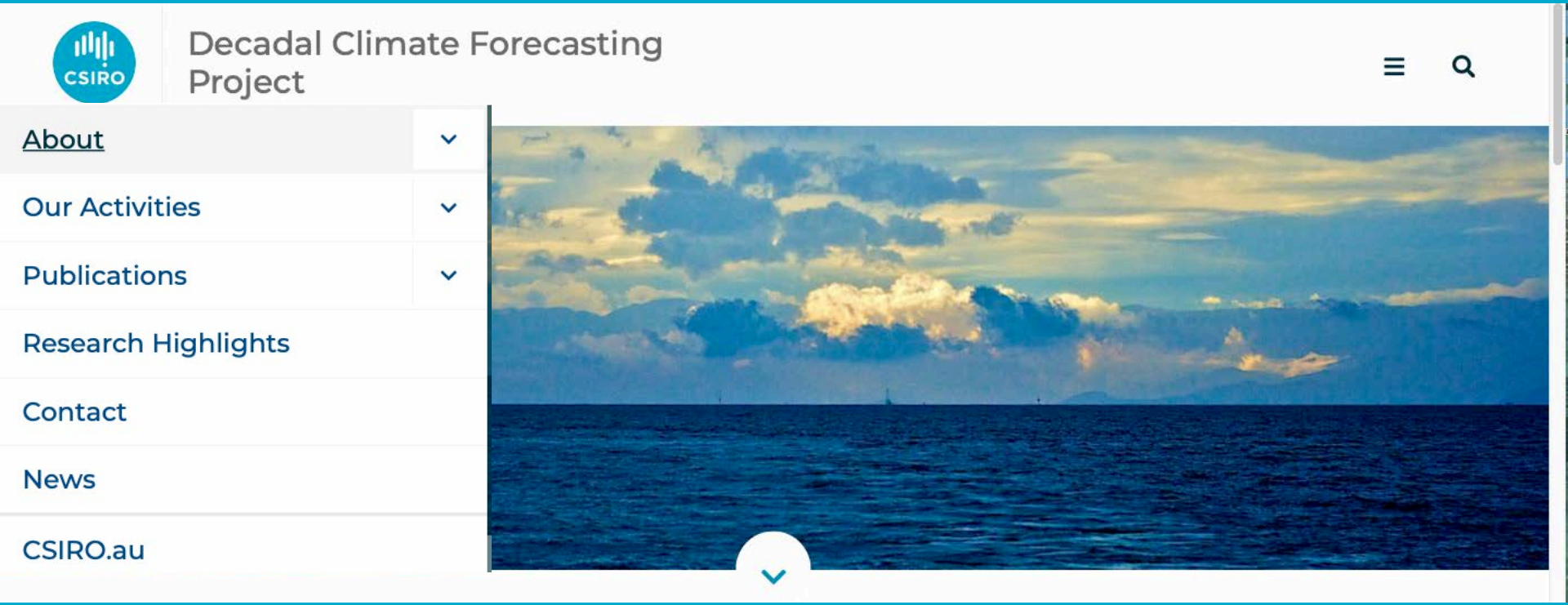


Climate forecasting and drought

- Understanding: Why do they form?
  - react to the right things, not the wrong things
- Changes in the odds: Is drought more likely this year(s)?
  - make better tactical decisions
- Updating and expanding the tail: updating our odds of drought in the current decade
  - generate very large ensemble forecasts
  - pool the forecasts into a super-ensemble
  - assess extreme likelihoods in sample rich ensemble
- Codesign to address strategic decisions


?
NDRISC / NBIC
MDB
National Res Centre for Disaster Resilience
Climate Services for Australia
NESP
Future Drought Fund
Drought Mission
Climate Change Mission
Climate Services for Ag

External Website: https://research.csiro.au/dfp/



DECADAL CLIMATE FORECASTING PROJECT

CLIMATE ANALYSIS FORECAST ENSEMBLE system