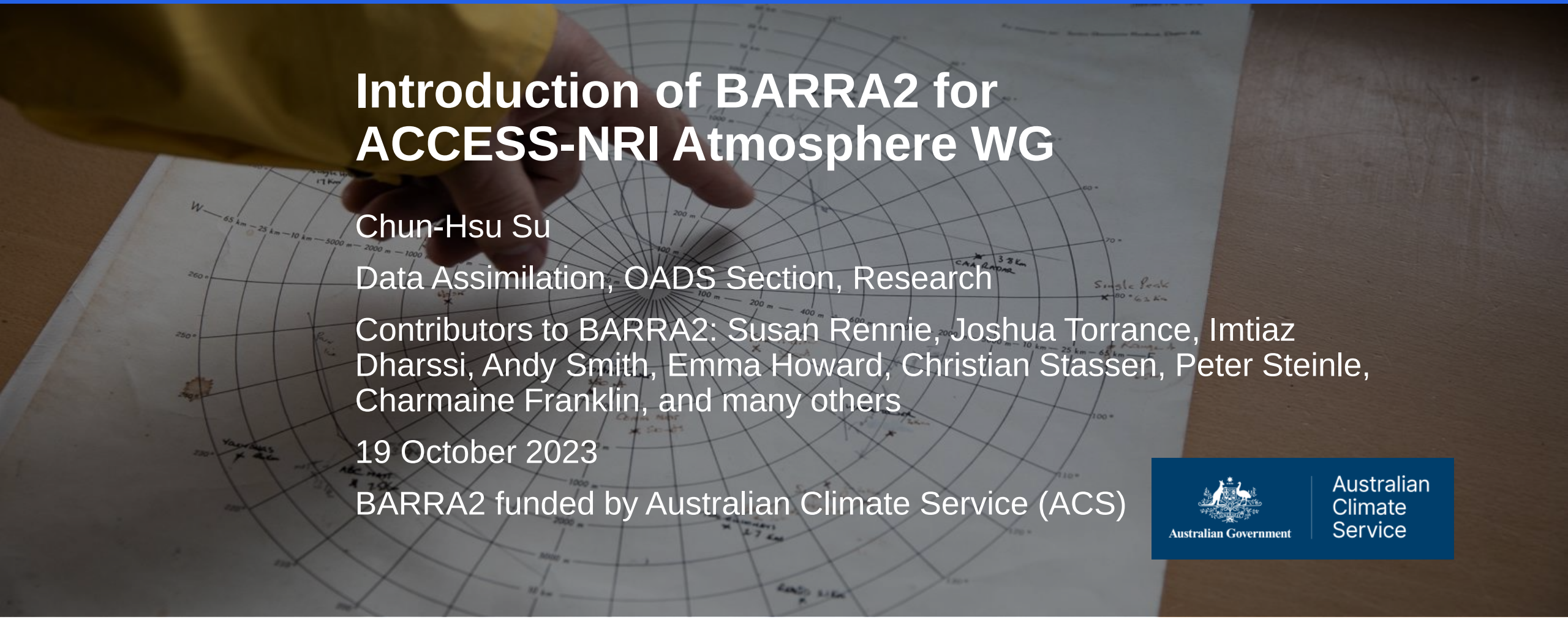
The Bureau of Meteorology



Introduction of BARRA2 for ACCESS-NRI Atmosphere WG

Chun-Hsu Su

Data Assimilation, OADS Section, Research

Contributors to BARRA2: Susan Rennie, Joshua Torrance, Imtiaz Dharssi, Andy Smith, Emma Howard, Christian Stassen, Peter Steinle, Charmaine Franklin, and many others

19 October 2023

BARRA2 funded by Australian Climate Service (ACS)

Australian Government | Australian Climate Service

Atmospheric reanalysis

What for: Provides as much information about past weather and climate using as much information available to us (in modelling physics and observations)

How to reconstruct past weather and climate:

Input: Integrator of most available sub-daily observations and gridded observations prepared as boundary or forcing

Output: Accessible and accurate* "maps without gaps" of 3D atmosphere over several years-decades

As for BARRA2

Surface stations, ships, buoys, aircrafts, sondes, satellite (radiances, wind retrievals, GNSS, soil moisture retrievals), TC tracks
(Data assimilation)

SST, land use/cover, vegetation, aerosols climatology ("Forcing")

- Sub-hourly, hourly, 3-hourly, daily, monthly
- Surface (temperature, precipitation, energy & water fluxes, runoff)
- Pressure-levels (temp, wind, moisture, cloud, pressure)
- Heights above surface (temp, wind)
- Sub-surface (soil moisture & temperature)
- Large-scale convection diagnostics: CAPE, CIN, LI,
- Lightning, updraft helicity, simulated reflectivity**

* Within observational and modelling uncertainty

* From km-scale models

Atmospheric reanalysis

What for: Provides as much information about past weather and climate using as much information available to us (in modelling physics and observations)

How to reconstruct past weather and climate:

Practice:

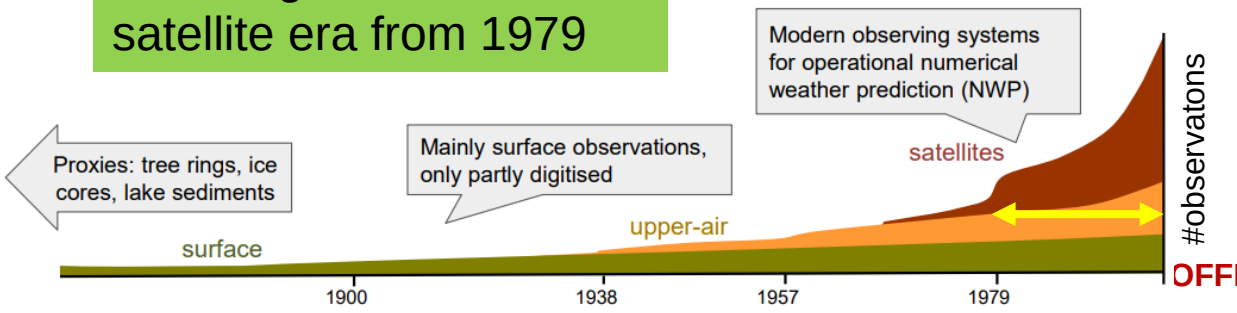
- Re-run analysis of (if possible) reprocessed observations and hindcast with a fixed DA/Modelling system for a long time period
- Post-process data to make the data accessible
- Made available to users in a convenient way
- Maintained close to NRT

As for BARRA2

```
/g/data/ob53
`-- BARRA2
    |-- output
        |-- reanalysis
            |-- AUS-11                  # BARRA-R2 Product
            |   |-- BOM
            |       |-- ERA5
            |           |-- historical
            |               |-- hres
            |                   |-- BARRA-R2
            |                       |-- v1
            |                           |-- 1hr
            |                               |-- tas
            |                                   |-- latest
            |                                   |   |-- tas_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_1hr_202110-202110.nc
            |                                   |-- preliminary
            |                                       |-- tas_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_1hr_202110-202110_prelim.nc
```

Metadata standards CF1-10, ACDD-1.3, file format - netCDF4, Data Reference Syntax, NCI GeoNetwork catalog, license CC-BY-4 (TBC)

Covering the modern satellite era from 1979

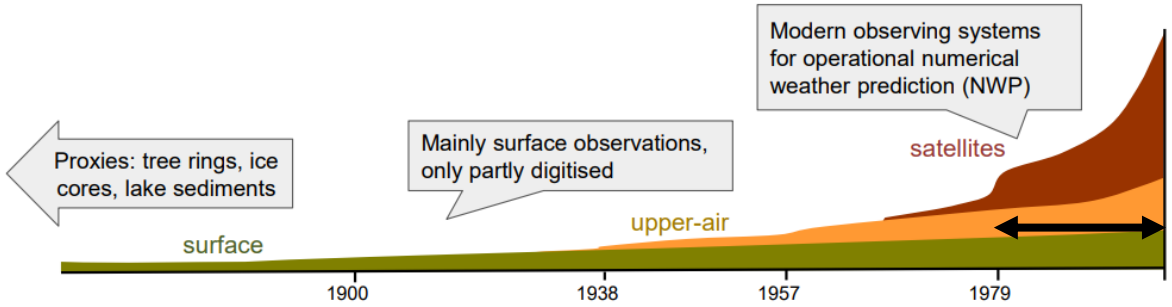


700Tb Gdata published in NCI Data Collection, THREDDS, GeoNetwork, ACS Data Portal (?)

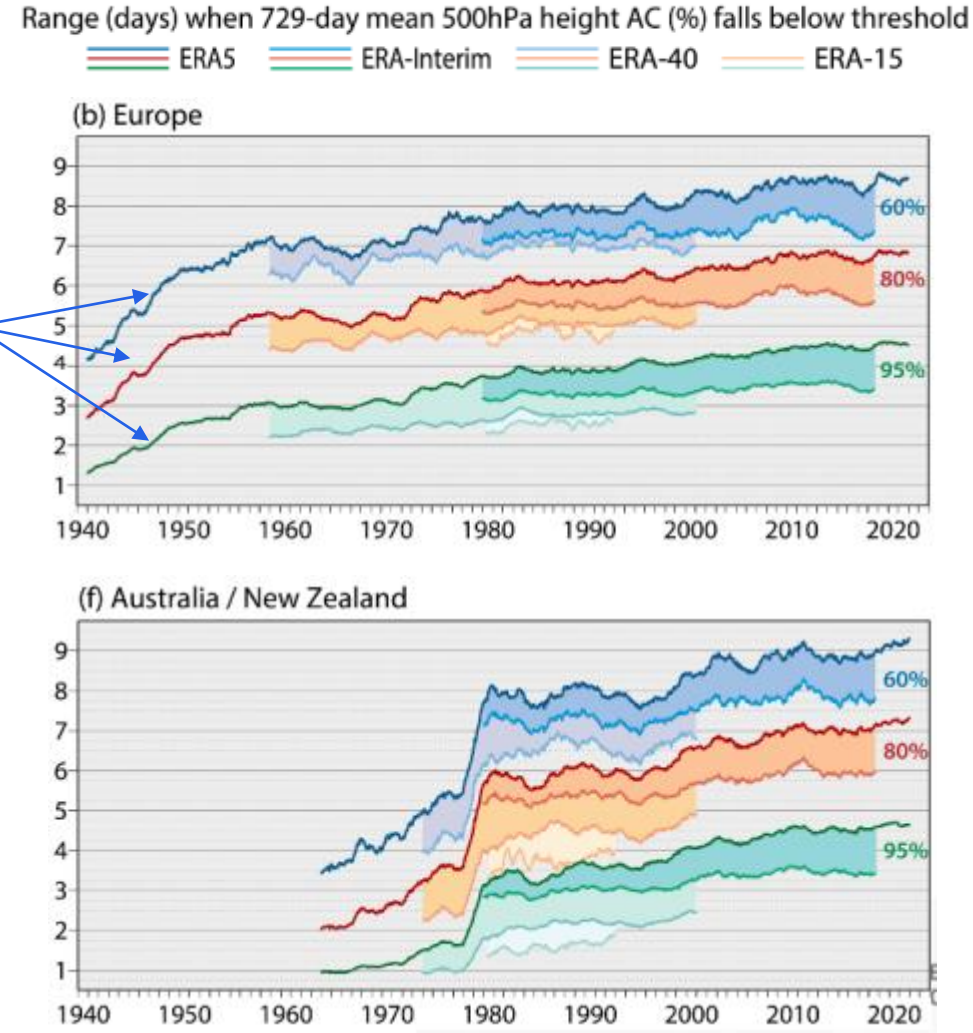
Update run keeping BARRA2 up to date, 3-4 months behind present day, e.g., June 2023 data available. This may improve to ~5 days in the future.

OFFICIAL

Changes in skills of reanalysis over time based on observation changes



Skill of ERA5



Major changes in the observing systems:

- 1979 – TOVS satellites
- 1998 – ATOVS satellites
- 2002 – First hyperspectral instrument
- 2006 – Large amounts of radio-occultation (anchor) observations

Images from ECMWF, Hersbach et al.

About BARRA2

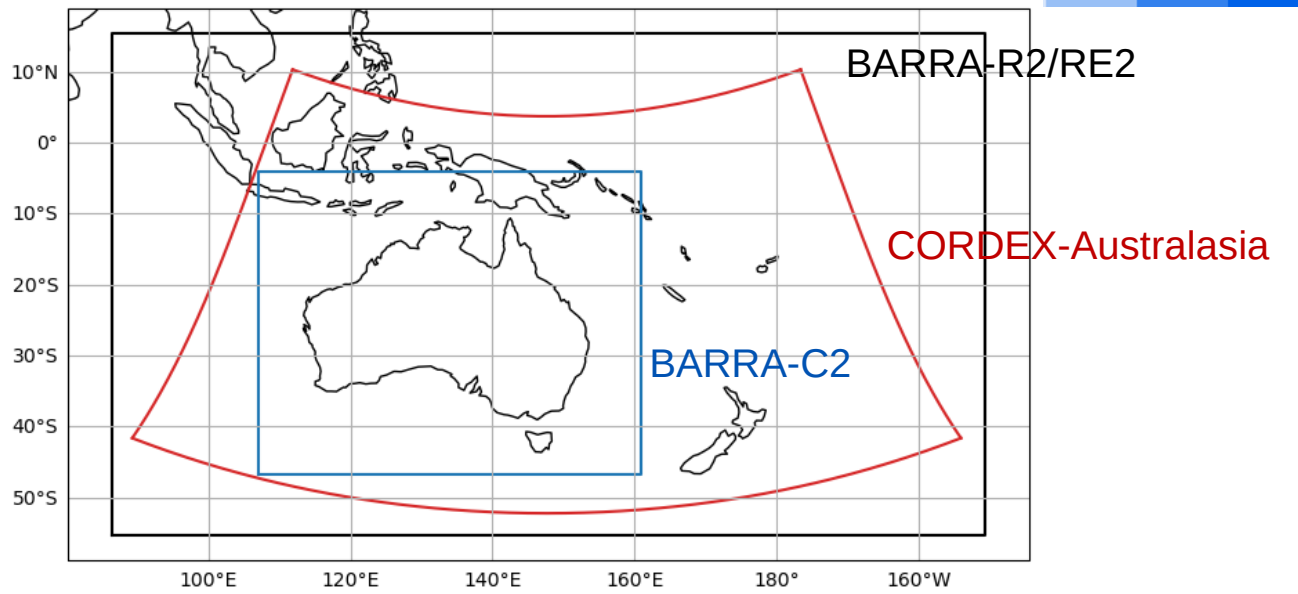
BARRA-R2/RE2 is a 12 km reanalysis (R2) & 24 km 22 lagged-member ensemble (RE2)

- Based on GA7.2/GL8.1 (PS44) science, over *CORDEX-Australasia* domain
- R2 - Nested in ERA5 HRES boundary & SST
- R2 – 6-hourly 4D-Var as with BARRA-R1
- RE2 – Nested in ERA5 EDA, with EDA perturbations
- Climatological land use/cover, vegetation, aerosols
- Parameterised convection

BARRA-C2 is a 4.4 km downscaled reanalysis

- Based on latest RAL3.2 science over Australia, following ACCESS-A (new NWP)
- Initial conditions and boundary from BARRA-R2
- Climatological land use/cover, vegetation, aerosols
- Explicit convection

BARRA2 domains



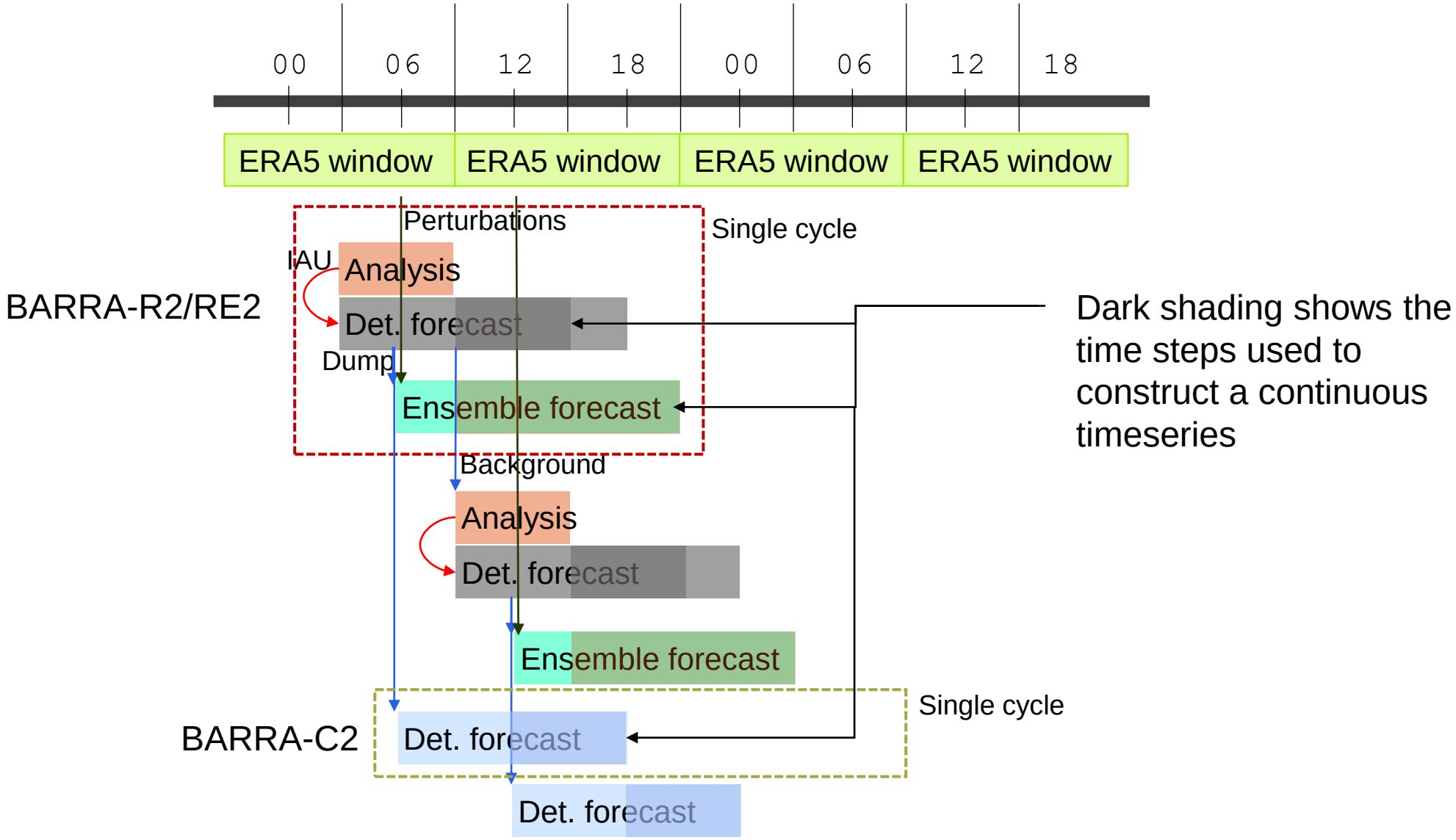
Comparing BARRA2 with BARRA1

	BARRA-R2	BARRA-RE2	BARRA-C2	BARRA-R1	BARRA-C1
Final range	1979-present	1979-present	1979-present	1990-2018	1990-2018
Realisations	1	22	1	1	1
Bound. Cond.	ERA5 HRES	ERA5 EDA	BARRA-R2	ERA-Interim	BARRA-R1
Grid Spacing	11 km	22 km	4.4 km	11 km	1.5 km
Assimilation	4D-Var	None	None	4D-Var	None
Domain	CORDEX-Australasia	CORDEX-Australasia	All of Australia	Aus, NZ, SEA[5]	Adelaide, Perth, Sydney, Hobart

Other differences

	BARRA1	BARRA2
Spatial coverage at 12 km reanalysis – BARRA-R	Australia, NZ, SEA, India, SO	Australia, NZ, SEA
Spatial coverage at km reanalysis – BARRA-C	Sydney, Perth, Adelaide, Tasmania	National coverage
Time period	1990-2018	1979 to present
Ensemble for uncertainty	No	24 km ensemble
Driving model	ERA-Interim	ERA5 – a climate reanalysis
Observations	In situ stations, ships, aircrafts, sondes, satellites (GNSS, sounders, scatterometers), ground-based GNSS	As with BARRA1, but reprocessed data for sonde, satellite wind, and GNSS. Additional observations from satellites.
Soil moisture assimilation	No	Yes with ESA Climate Change Initiative product
Soil moisture initialisation	Ad-hoc	Offline land-surface model run
Data format	netCDF, organised as 6-hourly files in cj37	netCDF, monthly files in ob53

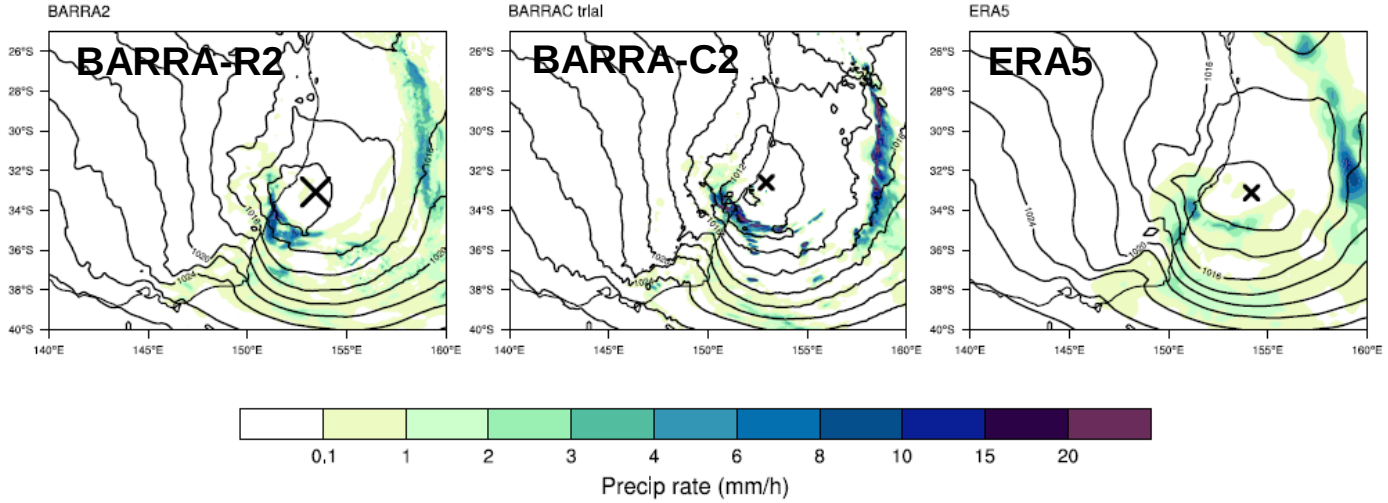
How is it being produced?



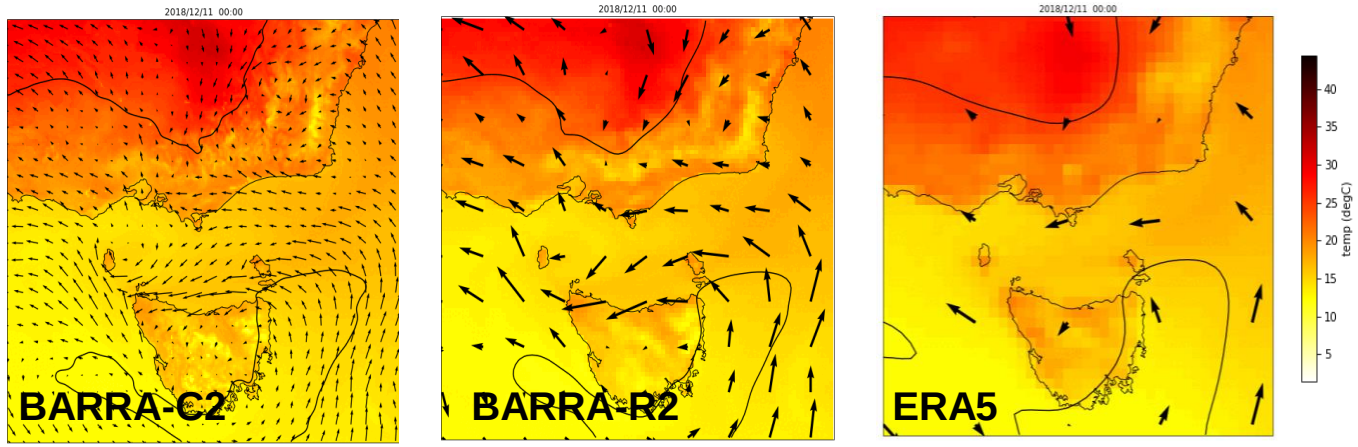
Dark shading shows the time steps used to construct a continuous timeseries

How does BARRA2 look?

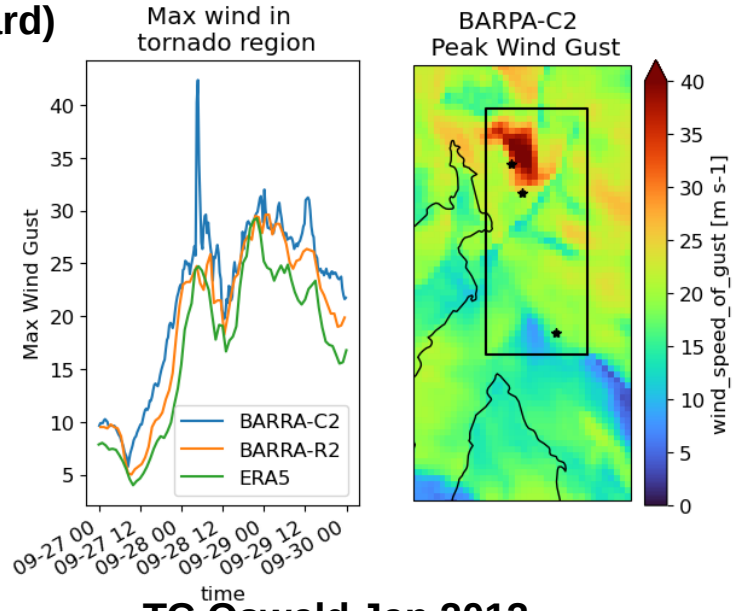
Dungog East Coast Low – TC Centre April 2015 (A Pepler)



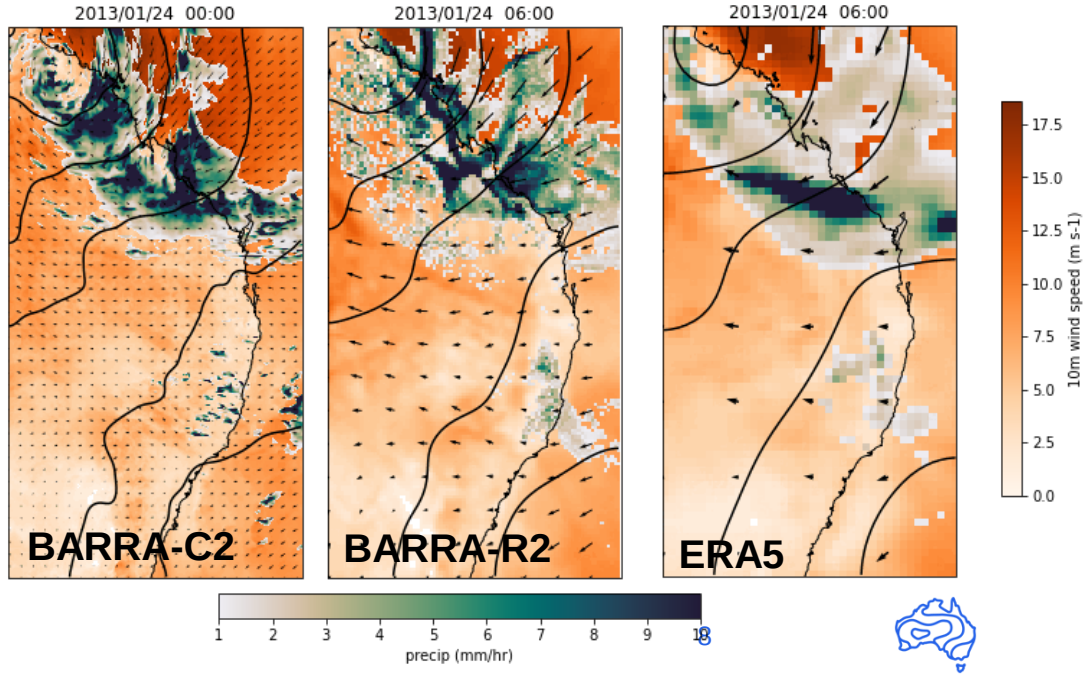
Heatwave Dec 2018



Convective wind gust SA Black Storm, Sep 2016 (E Howard)



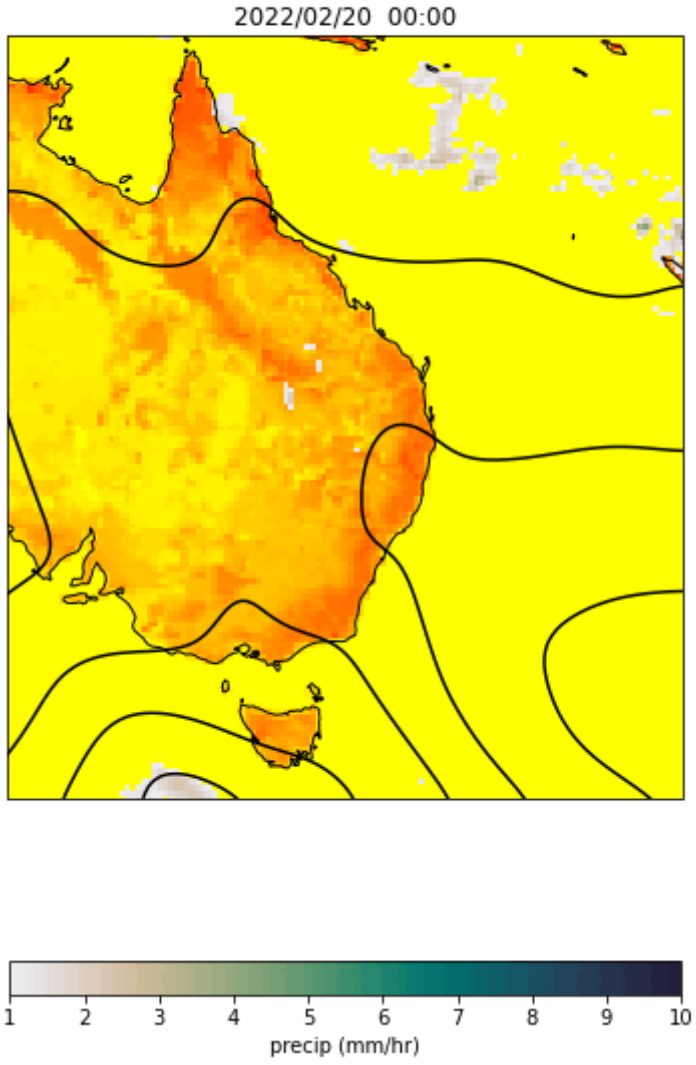
TC Oswald Jan 2013

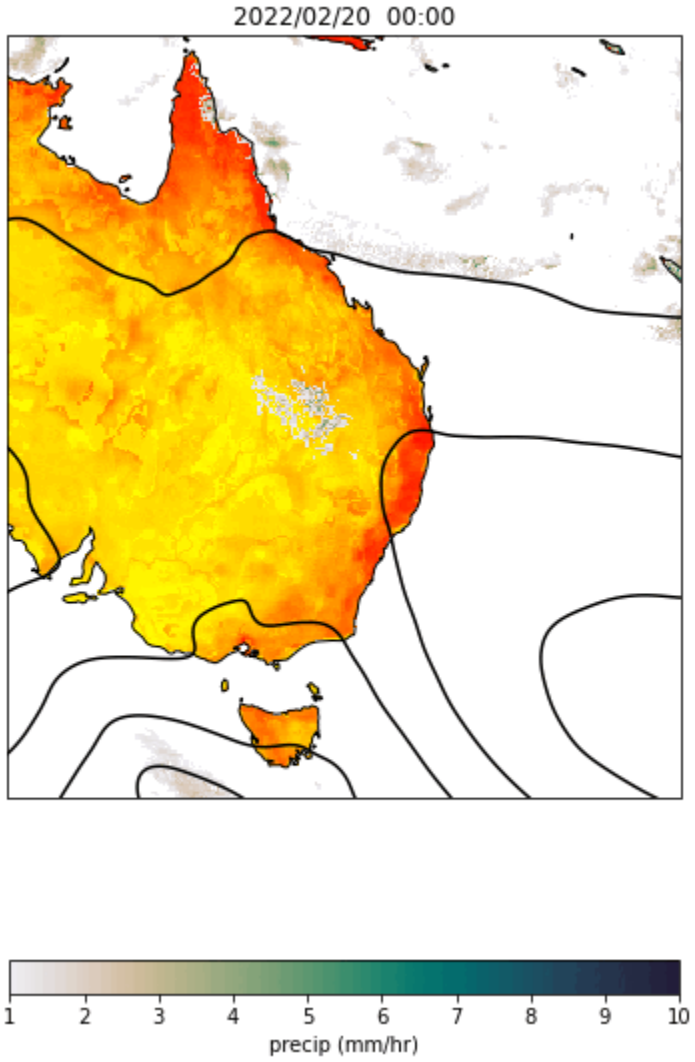


Eastern Australian floods 2022

Left: ERA5
Right: BARRA2

Soil Moisture
Precipitation
MSLP





Current Status

BARRA-R2/RE2 12km/24km

- Completed historical production run (1979-2022)
- Monthly update runs to keep up to date, 3-4 month behind present day
- To be released in NCI data collection (TBC CC-By-4), catalog on NCI Geonetwork, with DOI: Storage project created (ob53), data migration in progress
- Development data available in yb19 for prototyping and evaluation (see project description on conditions of use)

BARRA-C2 4.4 km

- Started production last week, expect to complete mid-2024
- (Will also have) Monthly update runs to keep up to date, 3-4 month behind present day
- To be released in NCI data collection, catalog on NCI Geonetwork: Storage project created (ob53), data migration in progress

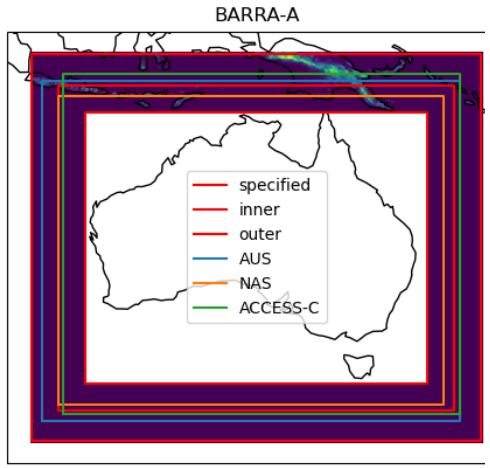
NCI gdata and THREDDS:

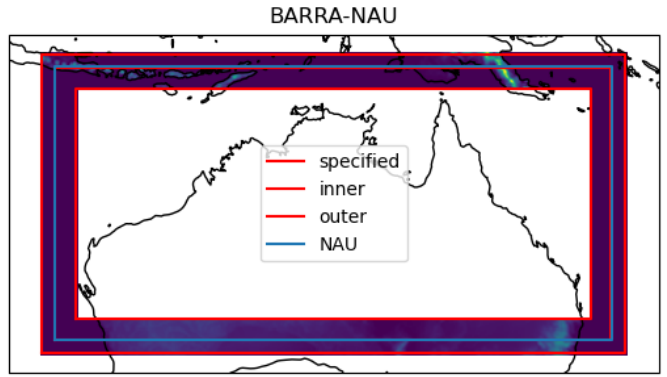
```
/g/data/ob53
`-- BARRA2
    |-- output
        |-- reanalysis
            |-- AUS-11                  # BARRA-R2 Product
            |   |-- BOM
            |       |-- ERA5
            |           |-- historical
            |               |-- hres
            |                   |-- BARRA-R2
            |                       |-- v1
            |                           |-- 1hr
            |                               |-- tas
            |                                   |-- latest
            |                                   |   |-- tas_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_1hr_202110-202110.nc
            |                                   |-- preliminary
            |                                       |-- tas_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_1hr_202110-202110_prelim.nc
            |
            |-- AUS-22                  # BARRA-RE2 Product
            |   |-- BOM
            |       |-- ERA5
            |           |-- historical
            |               |-- eda
            |                   |-- BARRA-RE2
            |                       |-- v1
            |                           |-- 3hr
            |                               |-- ta20
            |                                   |-- latest
            |                                   |   |-- ta20_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_3hr_202110-202110.nc
            |                                   |-- preliminary
            |                                       |-- ta20_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_3hr_202110-202110_prelim.nc
            |
            |
            |-- AUS-04                  # BARRA-C2 Product
                |-- BOM
                    |-- ERA5
                        |-- historical
                            |-- hres
                                |-- BARRA-C2
                                    |-- v1
                                        |-- mon
                                            |-- pr
                                                |-- latest
                                                |   |-- pr_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_mon_202111-202111.nc
                                                |-- preliminary
                                                    |-- pr_AUS-11_ERA5_historical_hres_BOM_BARRA-R2_v1_mon_202111-202111_prelim.nc
```

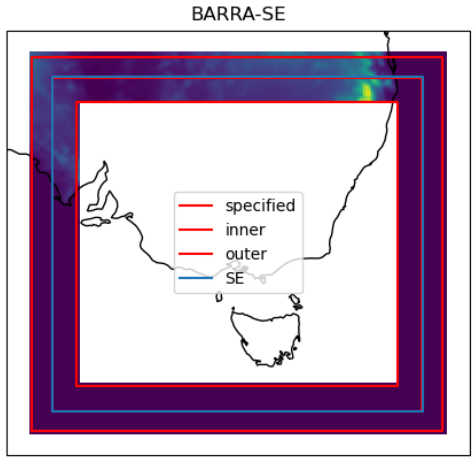
More data on NCI MDSS archive to support higher resolution modelling

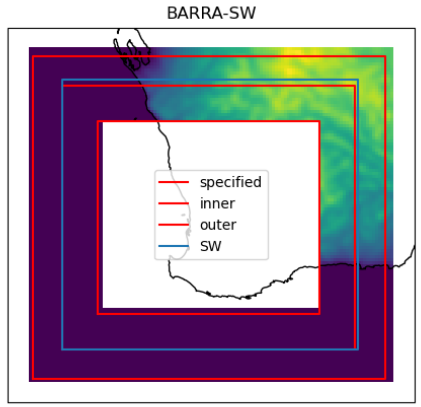
We also archived:

- Hourly boundary frames over predetermined domains – **as boundary conditions for BARRA-C2 or AUS2200**
- Analysis dumps at T= 0, 6, 12 and 18Z truncated over the 4 "framed" domains – **as initial conditions for BARRA-C2 or AUS2200**
- Start dump at T+3h over the whole domain – **to warm start BARRA-R2 and <u>re-run BARRA-R2 forecasts for creating required driving data for other domains within CORDEX</u>**



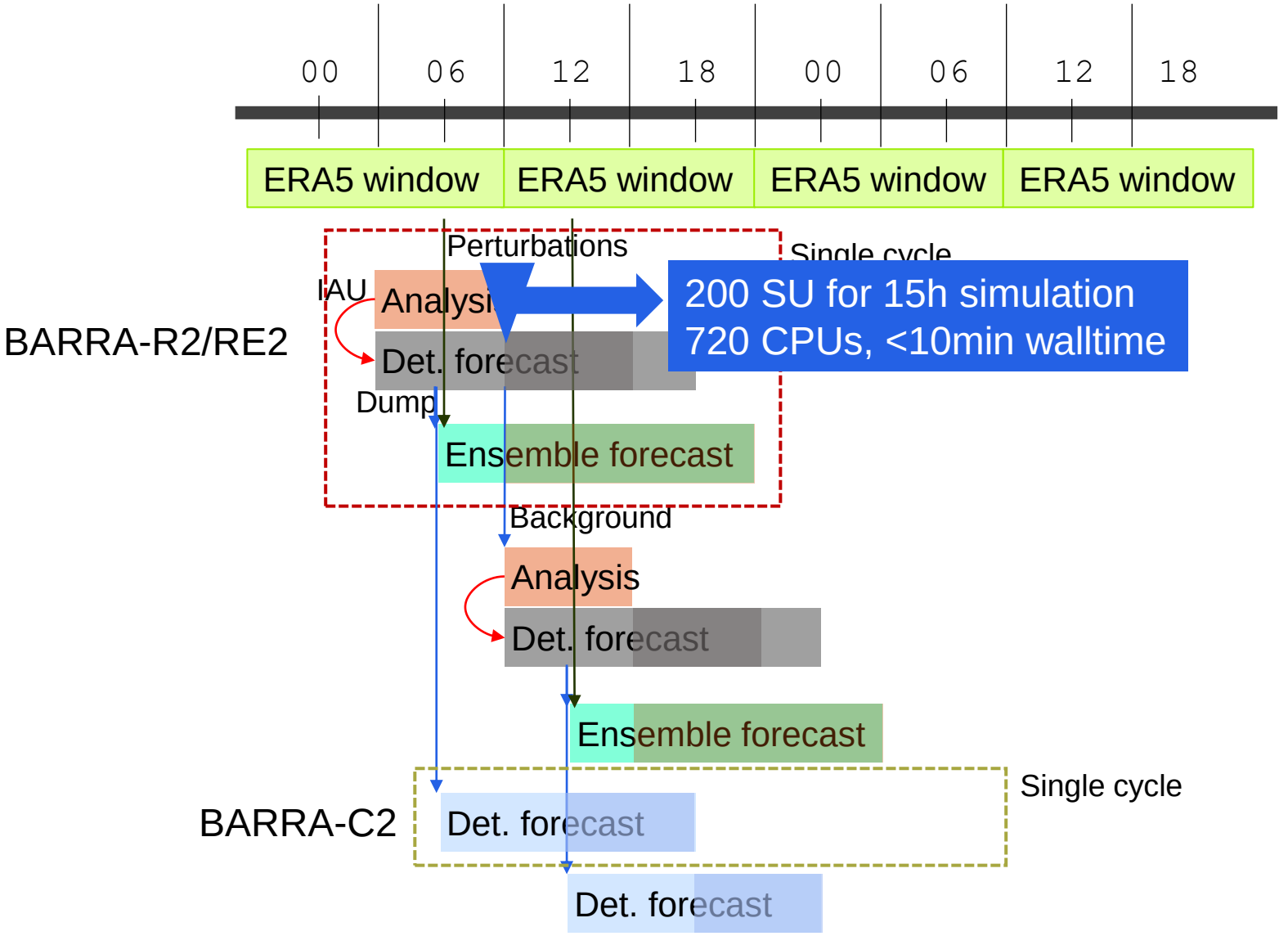






** At this time, contact me for retrieval of driving data for your experiments. Self-service may be possible in the future.*

Reforecasting with the archived T+3 dump



Coming soon

Data publication at NCI data collection (ob53)

		freq	variable	standard_name	long_name	units	cell_methods
2	1hr/rlds	1hr	rlds	surface_downwelling_longwave_flux_in_air	Surface Downwelling Longwave Radiation	W m-2	time: mean (interval: 1 hour)
3	1hr/clwvi	1hr	clwvi	atmosphere_mass_content_of_cloud_condensed_water	Condensed Water Path	kg m-2	time: point (interval: 1H)
4	1hr/clm	1hr	clm	cloud_area_fraction_in_atmosphere_layer	Mid Level Cloud Fraction	%	time: mean (interval: 1 hour)
5	1hr/va300	1hr	va300	northward_wind	Northward Wind	m s-1	pressure: point time: point (interval: 1H) area: interpolation (method: bilinear)
6	1hr/ua500	1hr	ua500	eastward_wind	Eastward Wind	m s-1	pressure: point time: point (interval: 1H) area: interpolation (method: bilinear)
7	1hr/prsn	1hr	prsn	snowfall_flux	Snowfall Flux	kg m-2 s-1	time: mean (interval: 1 hour)
144	3hr/zg20	3hr	zg20	geopotential_height	Geopotential Height	m	pressure: point time: point (interval: 3H) area: interpolation (method: bilinear)
145	3hr/hus70	3hr	hus70	specific_humidity	Specific Humidity	1	pressure: point time: point (interval: 3H) area: interpolation (method: bilinear)
146	3hr/snm	3hr	snm	surface_snow_melt_flux	Surface Snow Melt	kg m-2 s-1	time: mean (interval: 1 hour)
147	3hr/ta10	3hr	ta10	air_temperature	Air Temperature	K	pressure: point time: point (interval: 3H) area: interpolation (method: bilinear)
221	day/ta250m	day	ta250m	air_temperature	Air Temperature at 250m	K	model_level_number: point area: interpolation (method: bilinear) height: interpolation(method: log) time: point (i
222	day/zg925	day	zg925	geopotential_height	Geopotential Height	m	pressure: point time: point (interval: 3H) area: interpolation (method: bilinear) time: mean (interval: 1D)
223	day/ua400	day	ua400	eastward_wind	Eastward Wind	m s-1	pressure: point time: point (interval: 3H) area: interpolation (method: bilinear) time: mean (interval: 1D)
224	day/ua700	day	ua700	eastward_wind	Eastward Wind	m s-1	pressure: point time: point (interval: 3H) area: interpolation (method: bilinear) time: mean (interval: 1D)
225	day/rlus	day	rlus	surface_upwelling_longwave_flux_in_air	Surface Upwelling Longwave Radiation	W m-2	time: mean (interval: 1 hour) time: mean (interval: 1H) time: mean (interval: 1D)

Github for documenting known issues, 1h, 3h, day, mon field listing, FAQ (*send me your github username to join*)

AMOS 2024 Pre-Conference Workshop

Workshop: Accessing and using BARRA2 data for research

Monday 5 February

+ BARPA (regional climate projections) data

Convenors: Dr Joshua Torrance, Dr Chun-Hsu Su

This workshop will demonstrate how to access and navigate through the Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia version 2 (BARRA2) dataset available at NCI. The BARRA2 dataset provides researchers with historical long-term and spatially complete records of the atmosphere from 1979 to the present day. Participants will be guided on how to find information on, how to gain access to, and how to navigate through the BARRA2 datasets.

Participants are expected to have some familiarity with Python and will be guided through a series of demonstrative Python notebooks.

Final comments

More information

- Su et al., Bureau Research Report 067, BARRA2: Development of the next-generation Australian regional atmospheric reanalysis (bom.gov.au)
- Su et al., Bureau Research Report 084, Preliminary assessment of regional moderate-resolution atmospheric reanalysis for Australia (bom.gov.au)

Conditions of Use: Being early testers and users, we would like to ask for feedback from you on the quality and your usage of the data, to help us identify areas for improvements and for us to advise appropriate use of the data. Please contact Chun-Hsu Su, chunhsu.su@bom.gov.au.

We use GitHub, https://github.com/AusClimateService/BARRA2-data-release, to communicate BARRA2 data production, FAQ and known issues. Please email your GitHub username to Chun-Hsu Su for access to this GitHub.

Welcome collaborations.

The Bureau of Meteorology

Thank you

Chun-Hsu Su

chunhsu.su@bom.gov.au

Getting in touch on BARRA (reanalysis) or BARPA (projections)