Supplemental Material

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CAFE60v1: A 60-Year Large Ensemble Climate Reanalysis. Part I: System Design, Model Configuration, and Data Assimilation

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CAFE60v1: A 60-year large ensemble climate reanalysis. Part I: System design, model configuration and data assimilation: Supplemental tables and figures.

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ABSTRACT

We detail the system design, model configuration and data assimilation evaluation for the CSIRO Climate retrospective Analysis and Forecast Ensemble system: version 1. CAFE60v1 has been designed with the intention of simultaneously generating both initial conditions for multi-year climate forecasts and a large ensemble retrospective analysis of the global climate system from 1960 to present. This document provides supplemental materials to the accompanying manuscript "CAFE60v1: A 60-year large ensemble climate reanalysis. Part I: System design, model configuration and data assimilation".

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TABLE 1: Atmospheric variables

Variable	abbreviation	units	temporal resolution
`evap`	evaporation rate	kg/m2/s	daily, monthly
`lwflx`	net (down-up) longwave flux	w/m2	daily, monthly
`shflx`	sensible heat flux	w/m2	daily, monthly
`tau_x`	zonal wind stress	pa	daily, monthly
`tau_y`	meridional wind stress	pa	daily, monthly
`t_ref`	temperature at 2 m	deg_k	daily, monthly
`q_ref`	specific humidity at 2 m	kg/kg	daily, monthly
`u_ref`	zonal wind component at 10 m	m/s	daily, monthly
`v_ref`	meridional wind component at 10 m	m/s	daily, monthly
`t_surf`	surface temperature	deg_k	daily, monthly
`t_ref_min`	min temperature at 2 m	deg_k	daily, monthly
`t_ref_max`	max temperature at 2 m	deg_k	daily, monthly
`ps`	surface pressure	Pa	daily, monthly
`slp`	sea-level pressure	Pa	daily, monthly
`h500`	500-mb hght	m	daily, monthly
`hght`	geopotential height	m	daily, monthly
`sphum`	specific humidity	kg/kg	daily, monthly
`temp`	temperature	deg_K	daily, monthly
`ucomp`	zonal wind	m/sec	daily, monthly
`vcomp`	meridional wind	m/sec	daily, monthly
`omega`	omega	pa/sec	daily, monthly

TABLE 2: Atmospheric variables cont.

Variable	abbreviation	units	temporal resolution
DELP	delp field	pa	daily, monthly
wvp	Column integrated water vapor	kg/m2	daily, monthly
awp	Column integrated cloud mass	kg/m2	daily, monthly
precip	Total precipitation rate	kg/m2/s	daily, monthly
prec_conv	Precipitation rate from convection	kg(h2o)/m2/s	daily, monthly
rh	relative humidity	percent	daily, monthly
lwdn_sfc	LW flux down at surface	watts/m^2	daily, monthly
lwup_sfc	LW flux up at surface	watts/m^2	daily, monthly
olr	outgoing longwave radiation	watts/m^2	daily, monthly
qo3	ozone mixing ratio	kg/kg	daily, monthly
qo3_col	ozone column	DU	daily, monthly
swdn_sfc	SW flux down at surface	watts/m^2	daily, monthly
swup_sfc	SW flux up at surface	watts/m^2	daily, monthly
swdn_toa	SW flux down at TOA	watts/m^2	daily, monthly
swup_toa	SW flux up at TOA	watts/m^2	daily, monthly
vis_exopd_vl_c	visband column volcanic extopdep	dimensionless	daily, monthly
tot_cld_amt	total cloud amount	percent	daily, monthly

Note: some banding can be noticed about the Antarctic for certain mean atmospheric diagnostics. This is a diagnostic artefact and does not impact model dynamics.

TABLE 3: Ocean variables

Variable	abbreviation	units	temporal resolution
eta_t	surface height on T cells [Boussinesq (volume conserving) model]	m	daily, monthly
sss	Practical Sea Surface Salinity	psu	daily
sst	Potential Temperature at surface	°C	daily, monthly
mld	mixed layer depth determined by density criteria	m	daily
temp_vdiff_impl	implicit vert diffusion of heat	watts/m^2	monthly
salt_vdiff_impl	implicit vert diffusion of Practical Salinity	kg/(sec*m^2)	monthly
neutral_diffusion_temp	rho*dzt*cp*explicit neutral diffusion tendency (heating)	watts/m^2	monthly
neutral_diffusion_salt	rho*dzt*explicit neutral diffusion tendency for salt	kg/(sec*m^2)	monthly
neutral_gm_temp	rho*dzt*cp*GM stirring (heating)	watts/m^2	monthly
neutral_gm_salt	rho*dzt*GM stirring tendency for salt	kg/(sec*m^2)	monthly
age_global	Age (global)	yr	monthly
salt_sponge_tend	rho*dzt*tendency due to sponge	kg/(sec*m^2)	monthly
temp_sponge_tend	rho*dzt*cp*heating due to sponge	watts/m^2	monthly
salt	Practical Salinity	psu	monthly
temp	Potential temperature	°C	monthly
u	i-current	m/s	monthly
v	j-current	m/s	monthly
wt	dia-surface velocity T-points	m/s	monthly
tx_trans	T-cell i-mass transport	Sv (10-9 kg/s)	monthly
ty_trans	T-cell j-mass transport	Sv (10-9 kg/s)	monthly
tx_trans_gm	T-cell mass i-transport from GM	Sv (10-9 kg/s)	monthly
ty_trans_gm(	T-cell mass j-transport from GM	Sv (10-9 kg/s)	monthly
cfc_11	CFC-11	mol/kg	monthly
cfc_12	CFC-12	mol/kg	monthly

TABLE 4: Ocean forcing variables

Variable	abbreviation	units	temporal resolution
pme_net	precip-evap into ocean (total w/ restore + normalize)	$(kg/m^3)*(m/sec)$	monthly
river	mass flux of river (runoff + calving) entering ocean	$(kg/m^3)*(m/sec)$	monthly
evap	mass flux from evaporation/condensation (> 0 enters ocean)	$(kg/m^3)*(m/sec)$	monthly
fprec	snow falling onto ocean (> 0 enters ocean)	$(kg/m^3)*(m/sec)$	monthly
lprec	liquid precip (including ice melt/form) into ocean (> 0 enters ocean)	$(kg/m^3)*(m/sec)$	monthly
swflx	shortwave flux into ocean (> 0 heats ocean)	W/m^2	monthly
lw_heat	longwave flux into ocean (< 0 cools ocean)	W/m^2	monthly
sens_heat	sensible heat into ocean (< 0 cools ocean)	W/m^2	monthly
sfc_hflux_total	surface heat flux from coupler plus restore (omits mass transfer heating)	W/m^2	monthly
tau_x	i-directed wind stress forcing u-velocity	N/m^2	monthly
tau_y	j-directed wind stress forcing v-velocity	N/m^2	monthly

TABLE 5: Ocean scalar variables

Variable	abbreviation	units	temporal resolution
total_ocean_river	total liquid river water and calving ice entering ocean	kg/sec/1e15	monthly
total_ocean_evap	total evaporative ocean mass flux (> 0 enters ocean)	(kg/sec)/1e15	monthly
total_ocean_pme_sbc	total ocean precip-evap via sbc (liquid, frozen, evaporation)	kg/sec/1e15	monthly
total_ocean_fprec	total snow falling onto ocean (> 0 enters ocean)	(kg/sec)/1e15	monthly
total_ocean_lprec	total liquid precip into ocean (> 0 enters ocean)	(kg/sec)/1e15	monthly
total_ocean_calving	total water entering ocean from calving land ice	(kg/sec)/1e15	monthly
total_ocean_runoff	total liquid river runoff (> 0 water enters ocean)	(kg/sec)/1e15	monthly
salt_total	total mass of salt in liquid seawater	kg/1e18	monthly
temp_total	Total heat in the liquid ocean referenced to 0 °C	Joule/1e25	monthly
total_ocean_hflux_pme	total ocean heat flux from pme transferring water across surface	Watts/1e15	monthly
ke_tot	Globally integrated ocean kinetic energy	10^{15} Joules	monthly
pe_tot	Globally integrated ocean potential energy	10^{15} Joules	monthly
eta_nonbouss_globa	global average surface height nonboussinesq	m	monthly

TABLE 6: Ocean biogeochemical variables

Variable	abbreviation	units	temporal resolution
`no3`†	NO_3	mmol/m^3	monthly, daily for surface no3
`phy`†	phytoplankton	mmol/m^3	monthly, daily for surface phy
`o2`†	O_2	mmol/m^3	monthly
`det`†	detritus	mmol/m^3	monthly
`zoo`†	zooplankton	mmol/m^3	monthly
`caco3`†	Calcium Carbonate	mmol/m^3	monthly
`dic`†	Dissolved Inorganic Carbon	mmol/m^3	monthly
`alk`†	alkalinity	mmol/m^3	monthly
`adic`†	anthropogenic DIC	mmol/m^3	monthly
`fe`†	iron	mmol/m^3	monthly, daily for surface fe
`stf03`	Flux into ocean - oxygen	mmol/m^2/s	daily, monthly
`stf07`	Flux into ocean - DIC, PI	mmol/m^2/s	daily, monthly
`stf10`	Flux into ocean - DIC, inc. ADIC	mmol/m^2/s	daily, monthly
`pco2`	pCO_2		daily, monthly
`paco2`	anthropogenic pCO_2		daily, monthly
`pprod_gross_2d`	Vertically integrated Gross PHY production	mmolN/m^2/s	daily, monthly
`pprod_gross`	Gross PHY production	mmolN/m^3/s	monthly
`det_sediment`	Accumulated DET in sediment at base of water column	mmolN/m^2	monthly
`caco3_sediment`	Accumulated CaCO3 in sediment at base of water column	mmolN/m^2	monthly
`total_co2_flux`	Total surface flux of inorganic C (natural) into ocean"	Pg/yr	monthly
`total_aco2_flux`	Total surface flux of inorganic C (natural + anthropogenic) into ocean	Pg/yr	monthly

† indicates surface only variable is also avaialbe

TABLE 7: Land surface variables

Variable	abbreviation	units	temporal resolution
`cover_type`	Land surface cover type	dimensionless	monthly
`albedo`	albedo	dimensionless	monthly
`groundwater`	mass of water below bucket	kg/m^2	monthly
`latent`	latent heat flux	W/m^2	monthly
`precip`	total precipitation rate	$kg/(m^2\ s)$	monthly
`sens`	sensible heat flux	W/m^2	monthly
`smelt`	snow melt rate	$kg/(m^2\ s)$	monthly
`snow`	mass of snow on ground	kg/m^2	monthly
`snowfall`	snowfall rate	$kg/(m^2\ s)$	monthly
`water`	mass of water in bucket	kg/m^2	monthly
`sroff`	surface runoff of snow	$kg/(m^2\ s)$	monthly
`wroff`	surface runoff of water	$kg/(m^2\ s)$	monthly

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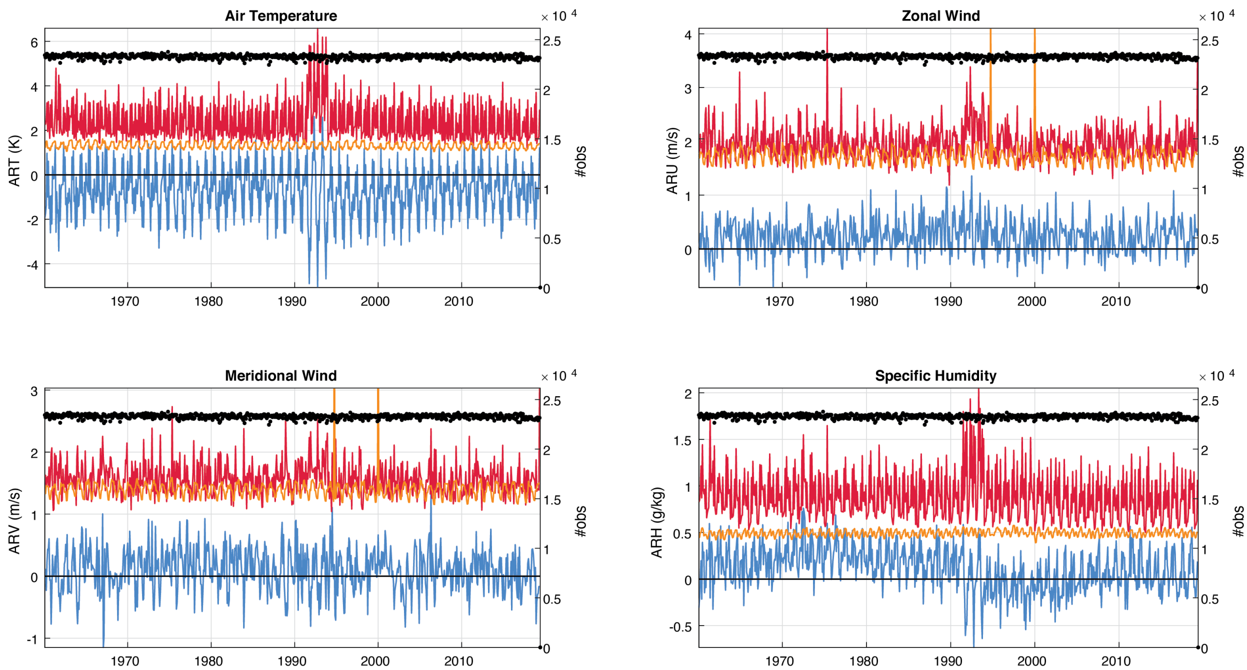

FIG. 1: Forecast mean absolute deviation (red) and bias (blue), ensemble spread (orange) and number of observations assimilated (black) for atmospheric air temperature, zonal and meridional wind and specific humidity.

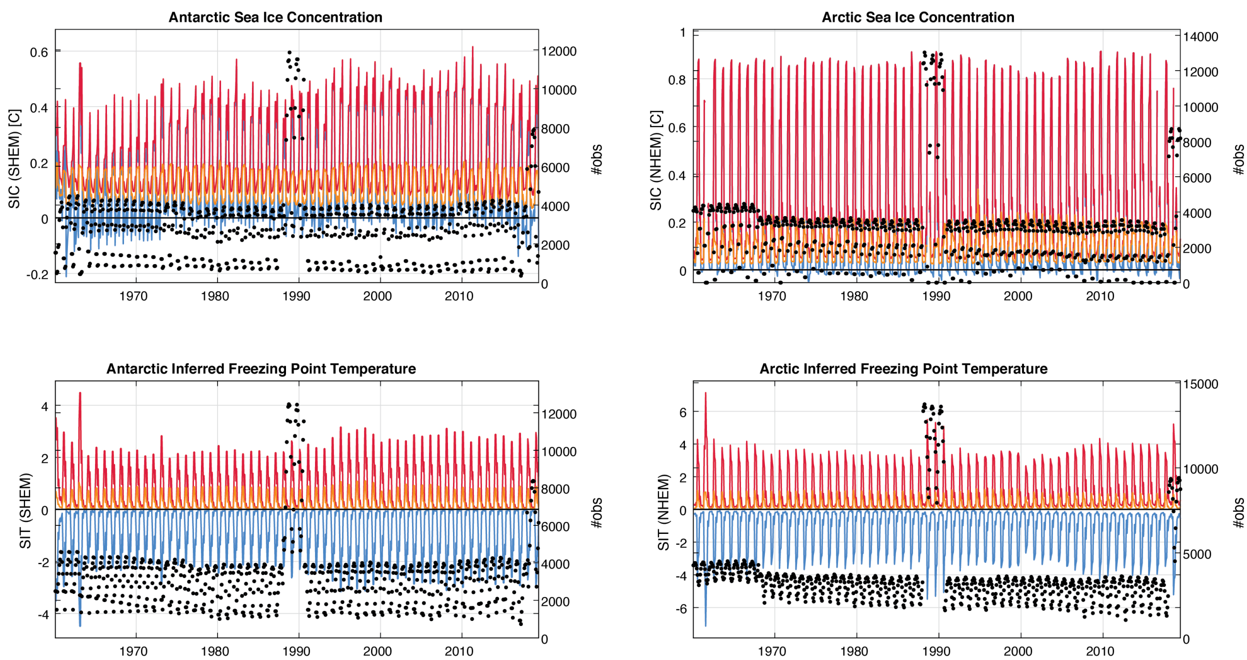

FIG. 2: Forecast mean absolute deviation (red) and bias (blue), ensemble spread (orange) and number of observations assimilated (black) for sea ice concentration and inferred under ice freezing point temperature in observation space.