WGSIP's Long-Range Forecast Transient Intercomparison Project: Framework and initial results

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WCRP World Climate Research Programme

HYDROMETEOROLOGICAL CENTRE OF RUSSIA

ИВМ ИНСТИТУТ ВЫЧИСЛИТЕЛЬНОЙ МАТЕМАТИКИ

BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

Environment and Climate Change Canada / Environnement et Changement climatique Canada

気象庁 Japan Meteorological Agency

Project framework

- WGSIP's Long-Range Forecast Transient Intercomparison Project (**LRFTIP**) is one of three current WGSIP projects, in addition to the long-term Climate System Historical Forecast Project (CHFP)
- Others are
  - **SnowGLACE**: Impact of snow initialisation on subseasonal-to-seasonal forecasts (Y. Orsolini and J.-H. Jeong co-leads)
  - **WGSIP teleconnection project** (L. Ferranti and A. Scaife co-leads)
- LRFTIP objectives include

  1) Developing an **online archive** of hindcast climatologies and related diagnostics

     from multiple systems including those contributing to S2S, CHFP, CMIP/DCPP

  2) Developing **standard set of diagnostics**

  3) **Addressing science questions**, including
     > influence of different initialization methods on transient behavior of climate system components
     > identification of any impacts (likely negative) on climate forecast quality

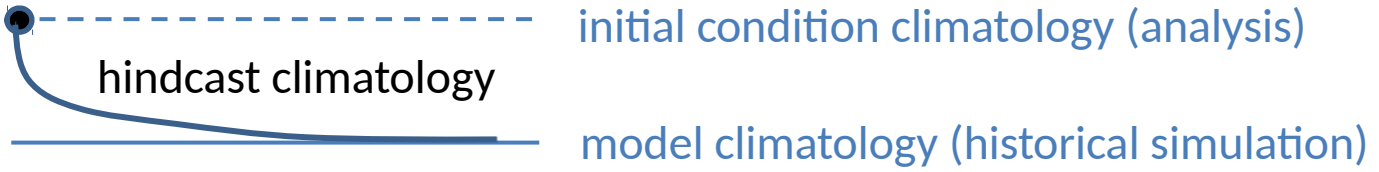
  4) Possibly at a later stage: **hindcast initialization experiments** (same model, different initialization methods) that will contribute to (1) and inform (2)

Ancillary reference climatologies

- When available, include also climatologies of
  1) Freely running model (ideally CMIP5 historical simulations, averaging over multiple ensemble members)
  2) Hindcast initial conditions, represented by assimilating model run or analysis used for initialization

•) Construct using same years as for hindcasts

•) These represent “endpoints” of hindcast drifts:



•) Differences with hindcast climatology will illustrate drifts away from IC, toward model climate

LRFTIP Data Request

The Long-Range Forecast Transient Intercomparison Project (LRFTIP):
Data Specifications

Version 1.4, 23 Feb 2016

ftp://dapp2p.cccma.ec.gc.ca/pub/goapp/LRFTIP/LRFTIP_Data_v1.4.pdf

- **Time scales considered**

Subseasonal forecasts: daily to 30 (60) days

Seasonal forecasts: daily to 30 (60) days + monthly through forecast range

Decadal forecasts: daily to 30 (60) days + monthly/annual through forecast range

- **Data format:** CF-compliant NetCDF
  - Time variable = **leadtime**
  - File, path names guided by **CMIP/ESGF conventions**

- **Variables and priorities** listed in Data Specifications

Overview of data request and priorities

Subseasonal

Start dates:

- Near 1st day of Nov, May – *Priority 1*
- Near 1st day of Feb, Aug – *Priority 2*

Frequency:

- Daily, forecast days 1-30 – *Priority 1*
- Daily, forecast days 31-60 – *Priority 2*

Variables:

- Tables **Atmosphere 2D** & **Atmosphere 3D**, priorities as indicated

Period:

- Climatological period spanning ≥ 15 years

Seasonal

Start dates:

- Near 1st day of Nov, Feb, May, Aug – *Priority 1*

Frequency:

- Daily, forecast days 1-30 – *Priority 1*
- Daily, forecast days 31-60 – *Priority 2*
- Monthly, through longest forecast range – *Priority 1*

Variables:

- **All data tables** with priorities as indicated

Period:

- Climatological period spanning 30 years (ideally 1981-2010) is preferred, other periods spanning ≥ 15 years acceptable

Overview of data request and priorities

Decadal

Start dates:

- At or shortly before the start of years 1961, 1966,…,2006, as per the CMIP5 Tier 1 decadal prediction experiment (Taylor et al. 2013), **OR**, at or shortly before the start of *N* consecutive years ($N \geq 15$) – *Priority 1*
- At or shortly before the start of consecutive years 1961…2010 – *Priority 2*

Frequency:

- Daily, forecast days 1-60 – *Priority 2*
- Monthly, calendar years 1-5 of forecast, plus any complete months preceding first full calendar year – *Priority 1*
- Monthly, calendar years 6-10 of forecasts – *Priority 2*
- Yearly, through longest forecast range (maximum 10 years) – *Priority 1*

Variables:

- **All data tables** with priorities as indicated

Period:

- CMIP5 Tier-1 hindcast period 1961…2006 for hindcasts initialized every 5 years ("decadal5")
- Flexible for CMIP5 or non-CMIP5 hindcasts sets initialized every year ("decadal1")

Data sources

Subseasonal: S2S

Seasonal: CHFP, ENSEMBLES

Decadal: CMIP5, DCPP/CMIP6 (in time)

Contributions from models/systems not contributing to the above projects are welcome & solicited!

Motivation: comparative assessment of shock/drift with that of other models

Current status of archive

Snapshot as of 28 April 2016

Decadal Prediction Data

Analysis / Initial Conditions

Decadal Predictions

Historical Simulations

Model	Atmosphere Daily	Atmosphere Monthly	Atmosphere Yearly	Ocean Monthly	Ocean Yearly
CCSM4				8 9	8 9
CERFACS-ENSEMBLES				11	11
CFSv2				7	7
CanCM4 i1		26 17	26 17	13 13 13	13 13 13
CanCM4 i2		26 17	26 17	13 13 13	13 13 13
ECMWF-ENSEMBLES				11	11
GFDL-CM2p1				11 11	11 11
HadCM3				6 6	6 6
IFM-ENSEMBLES				11	11
MIROC5				7	7

Current status of archive

Snapshot as of 28 April 2016

Seasonal Prediction Data

Analysis / Initial Conditions

Seasonal Predictions

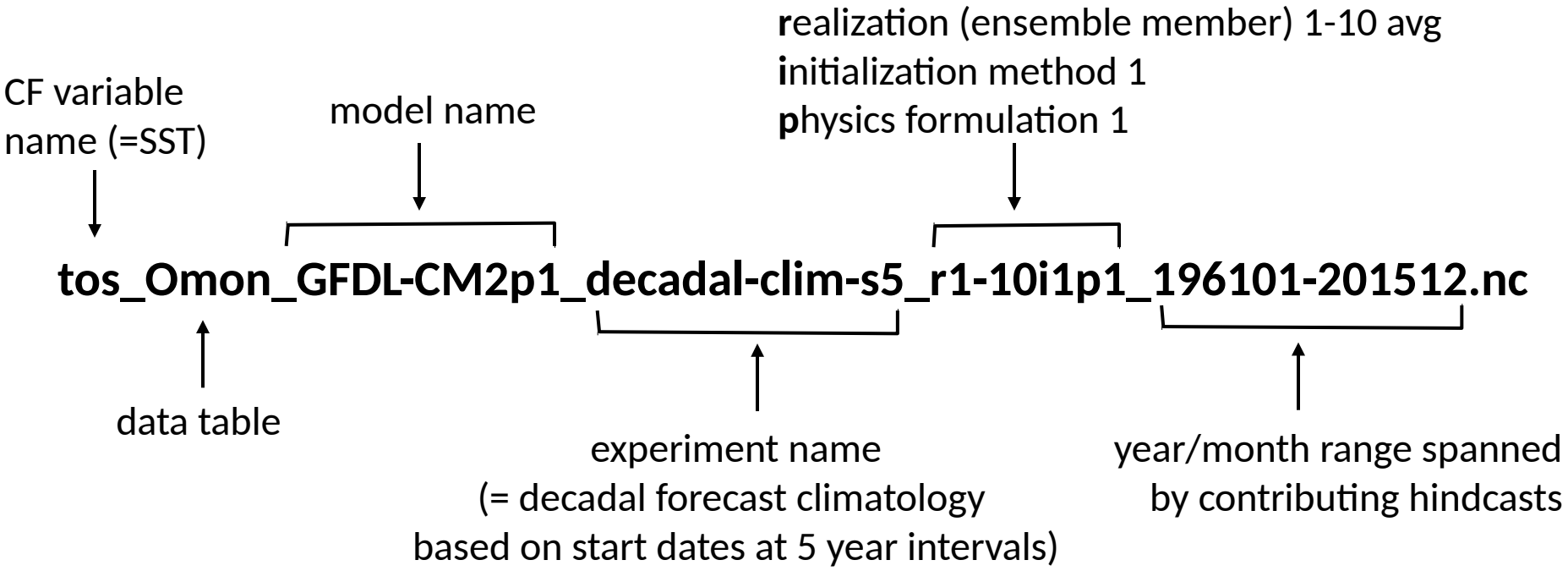
Historical Simulations

Model	Atmosphere Daily	Atmosphere Monthly	Ocean Monthly
CanCM3			12
CanCM4			12
JMAMRI-CGCM1			7
MIROC5_v1.0			7

Subseasonal Prediction Data

Model	Atmosphere Daily	Atmosphere Monthly
Calculation underway at INM/HMCR, will be archived at CCCma		

File naming convention



corresponding climatology for historical simulations:

tos_Omon_GFDL-CM2p1_historical-clim-s5_r1-10i1p1_196101-201512.nc

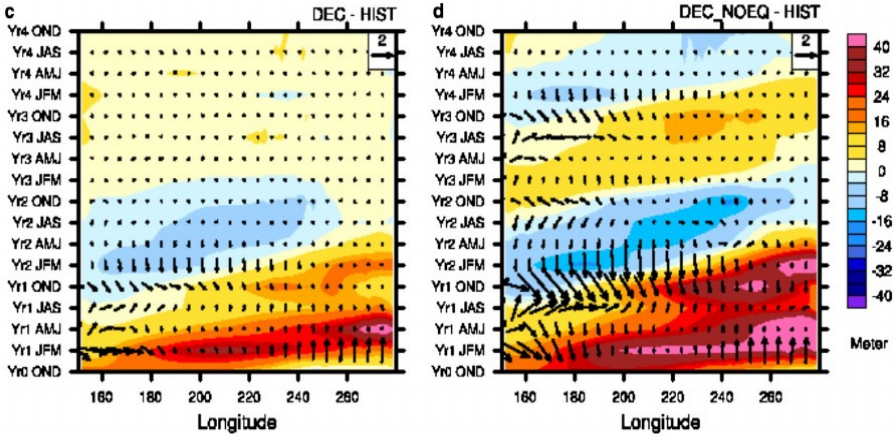
Planned: .nc → .nc4 (conversion to NetCDF4)

Hindcast diagnostics

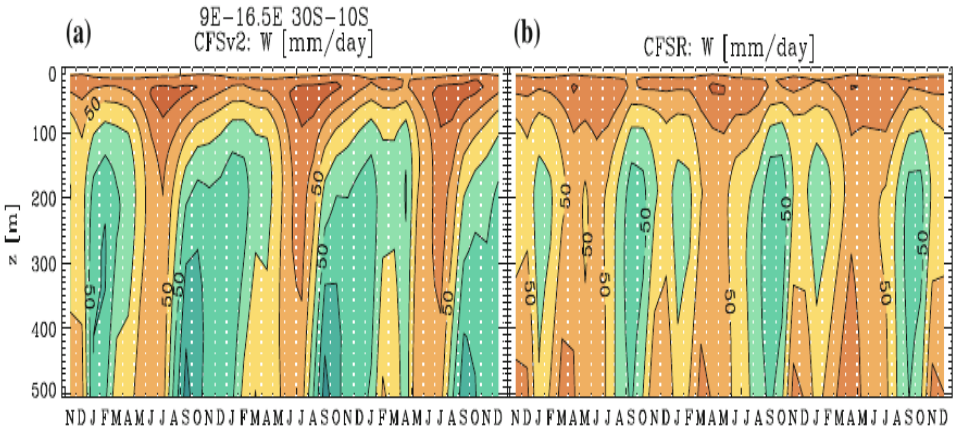
- Objective is to establish a standard set of diagnostics for hindcast climatologies, somewhat as was developed for model MJO behavior by the US Clivar MJO Working Group
- Archive will include
  - plots of diagnostics for available models in common format
  - R scripts used to produce plots
  - diagnostic data files
- Various levels of processing, including SST bias vs lead time, Hovmoller plots vs lead time, etc., drawing from existing literature
- Focus areas will include equatorial Pacific, North Atlantic

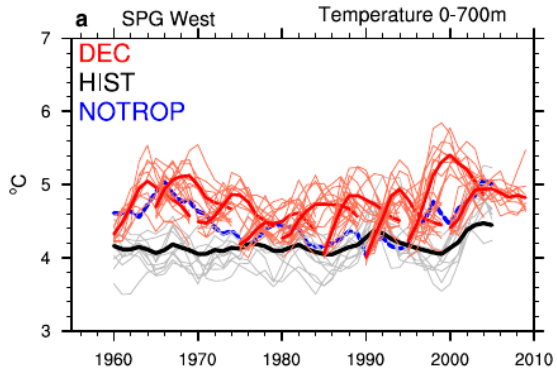
Some of the many hindcast climatology diagnostics examined in recent studies

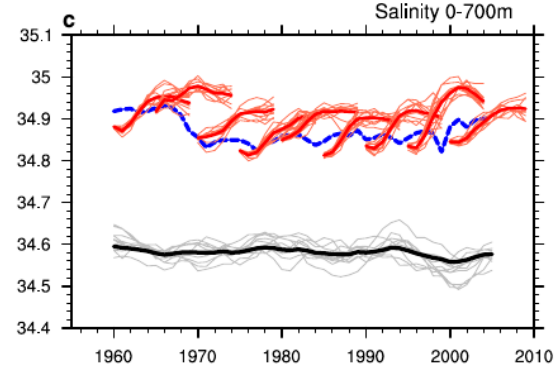
Sanchez-Gomez et al., *Clim. Dyn.,* 2015



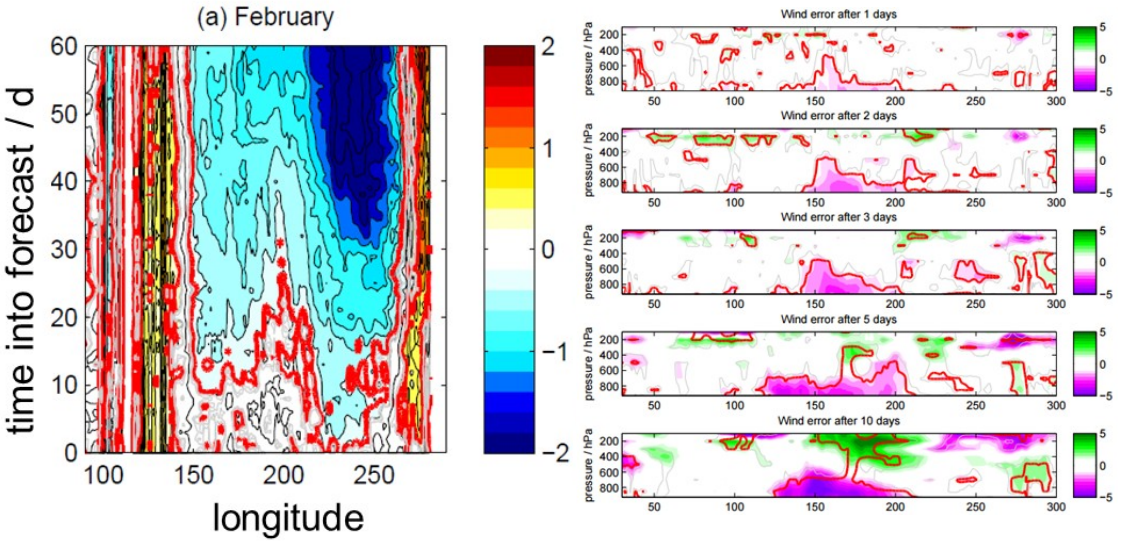
Toniazzo & Woolnough, *Clim. Dyn.,* 2014







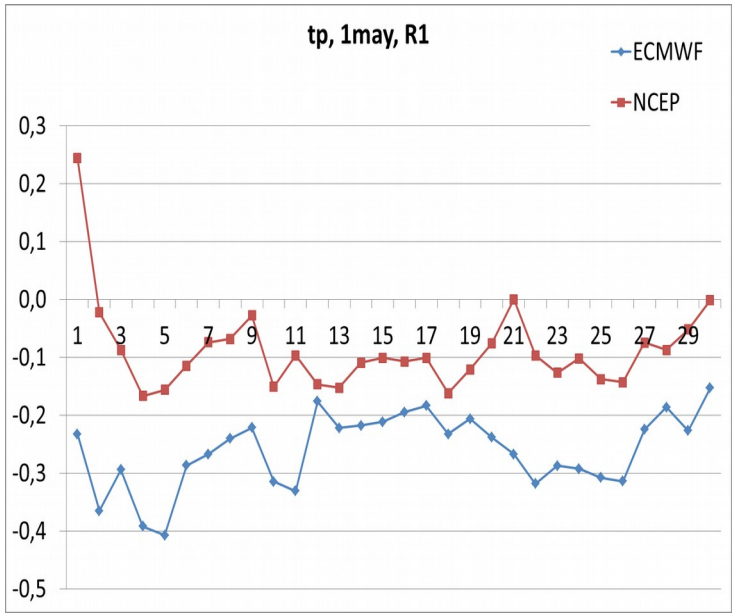
Shonk, *Presentation at WGSIP 17,* 2015

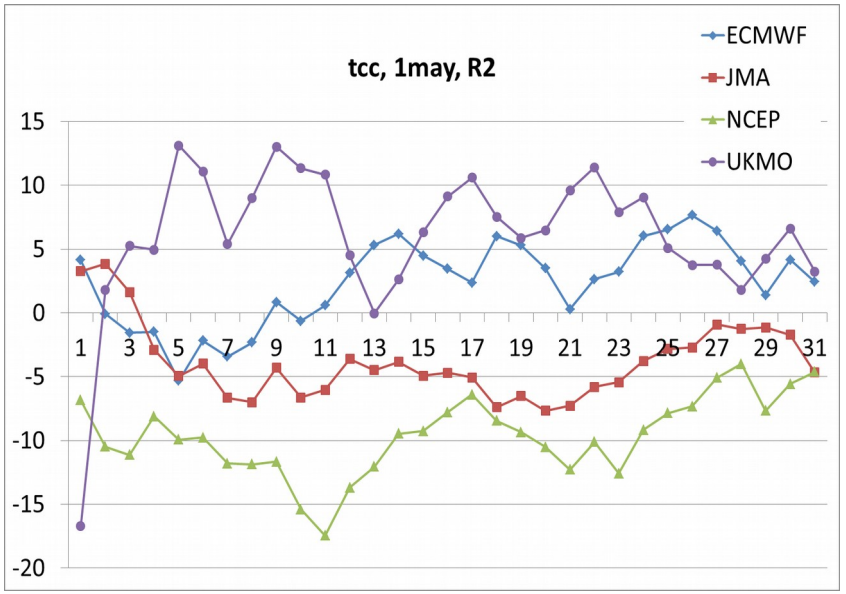


Subseasonal part of the Long-Range Forecast Transient Intercomparison Project

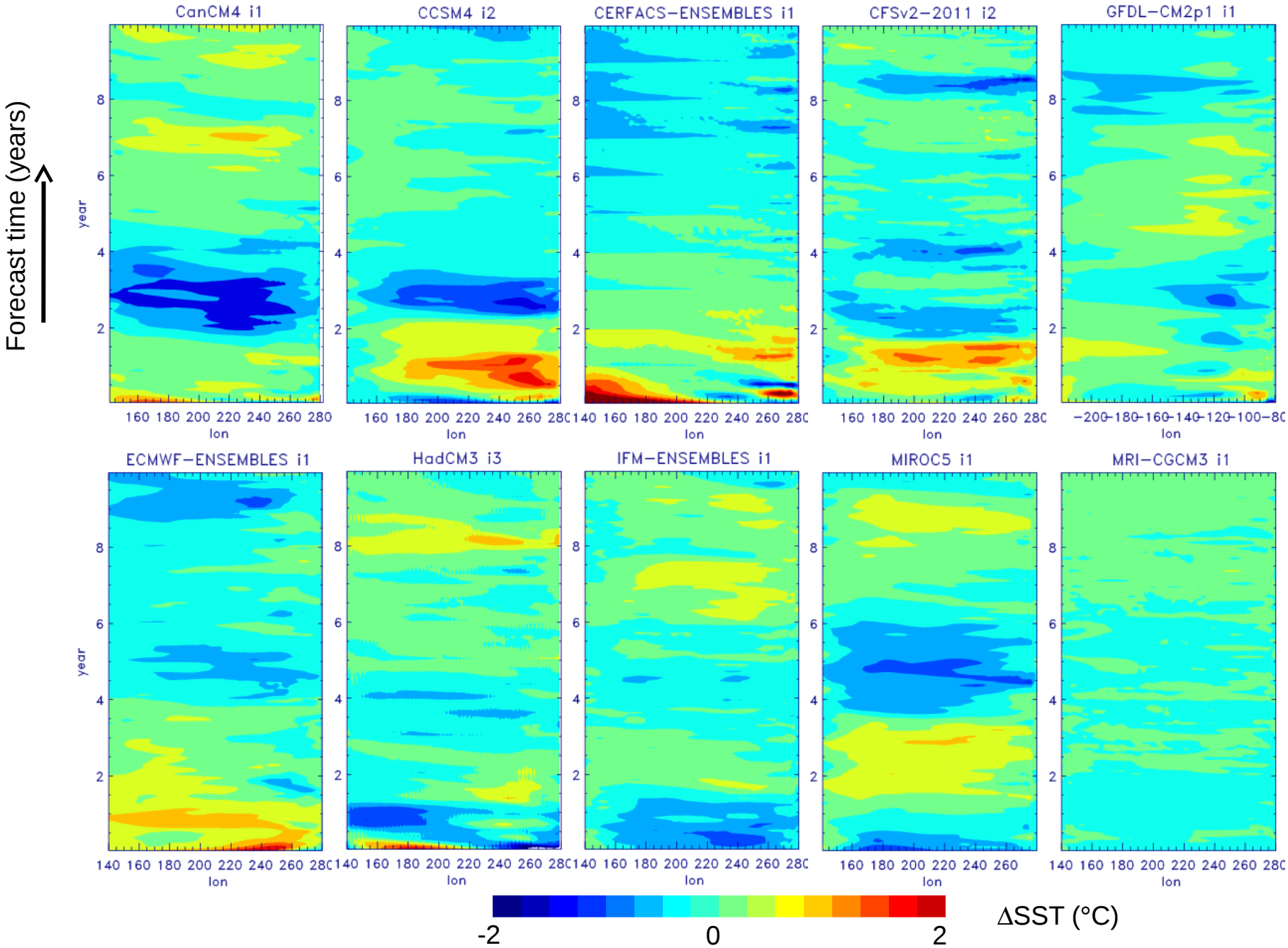
Mikhail Tolstykh, William Merryfield, Tatiana Krasjuk

- Creating an archive of daily hindcast climatologies produced by coupled models from the WMO S2S project database.
- Inform on transient behavior of initialized coupled prediction during 1st forecast month
- Starting dates 1st of May and 1st of November (+/-1day).
- Sample plots: averaged over 1996-2010 (1999-2010 for NCEP) daily anomalies w.r.t. reanalysis. Tropical Pacific precip (left) and North Atlantic total cloud cover (right) anomalies

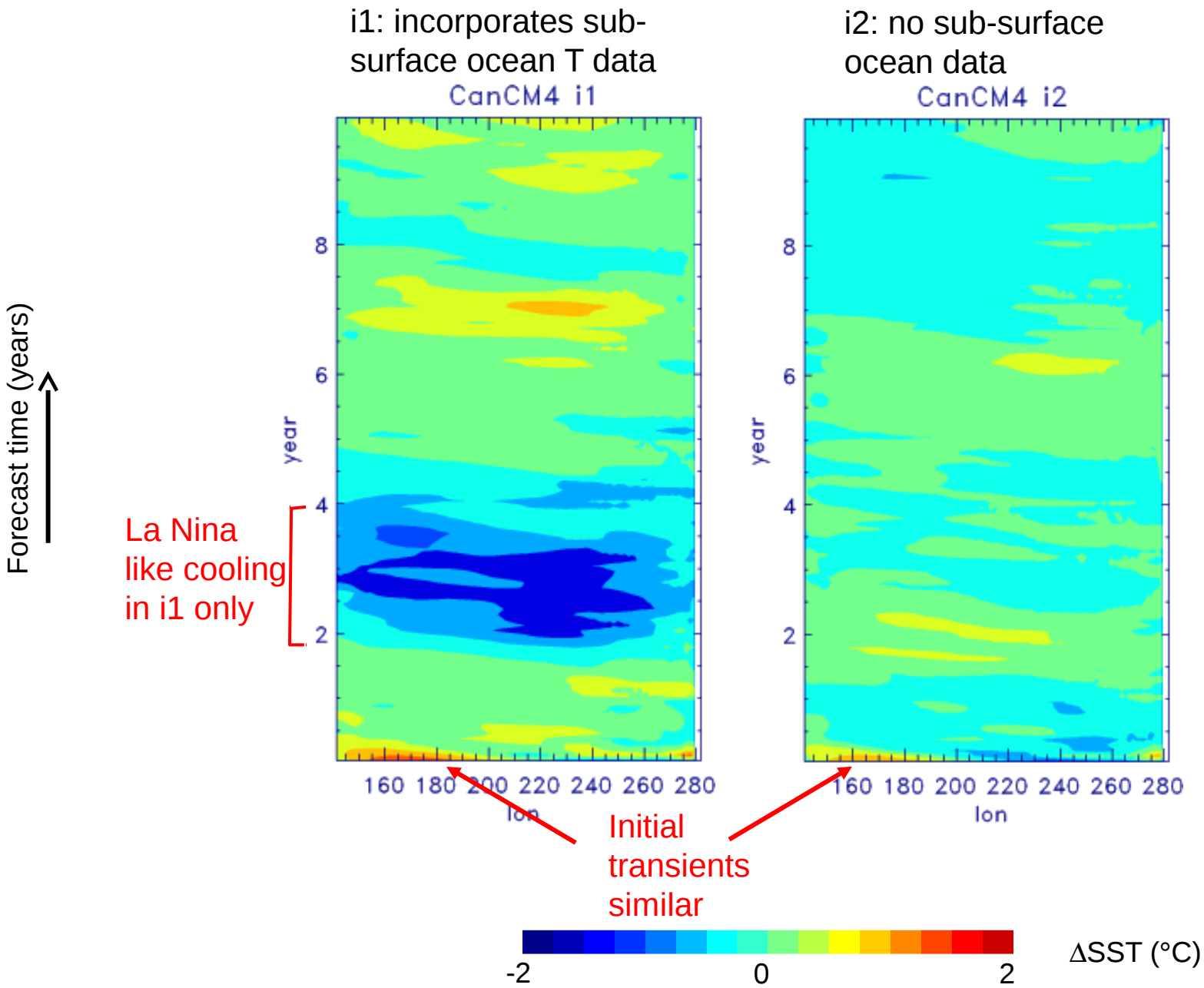




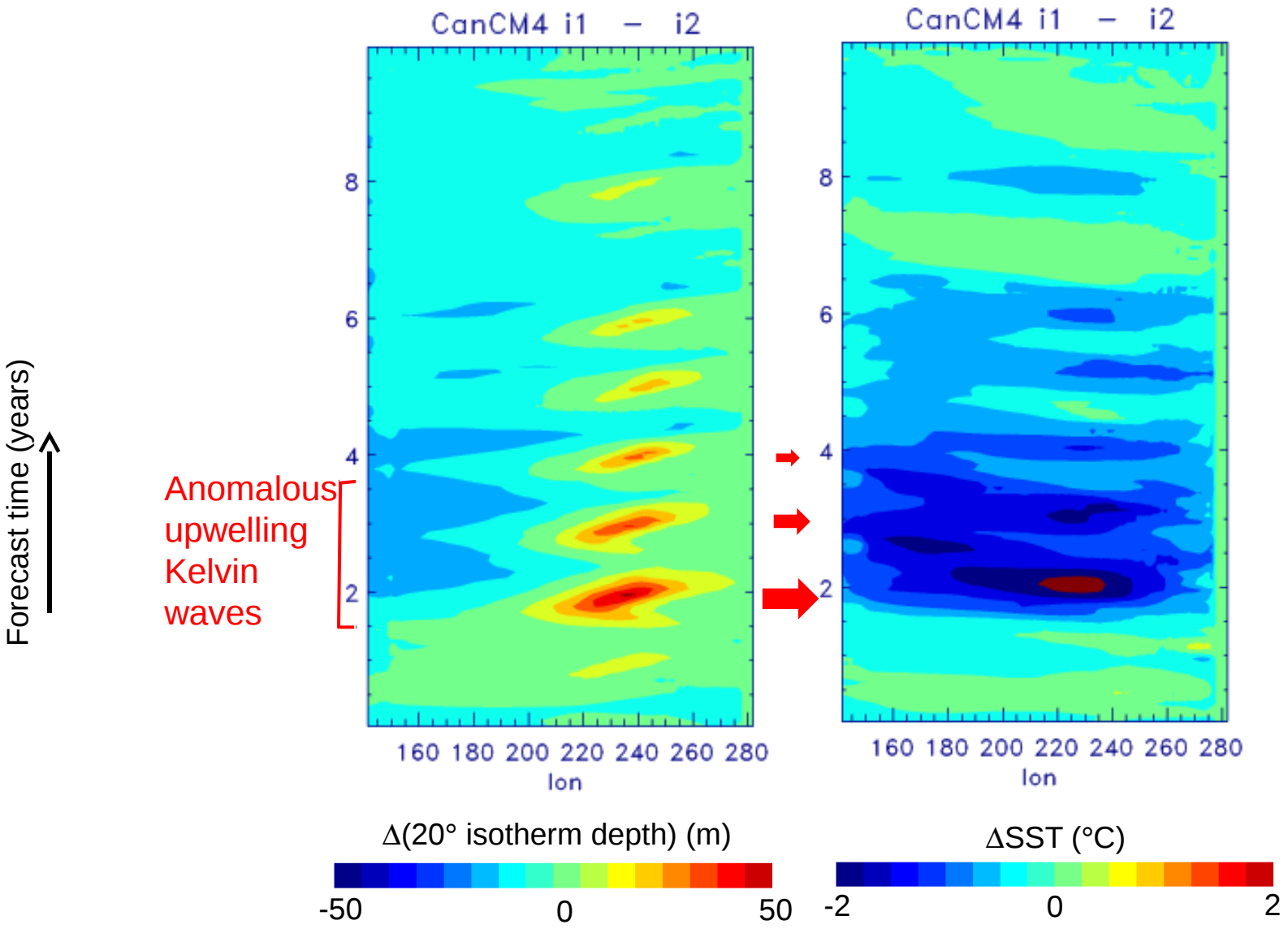
Evolution of SST decadal forecast climatology along equatorial Pacific for 10 models



Comparison of CanCM4 mean shock/drift for two initialization methods i1 vs i2

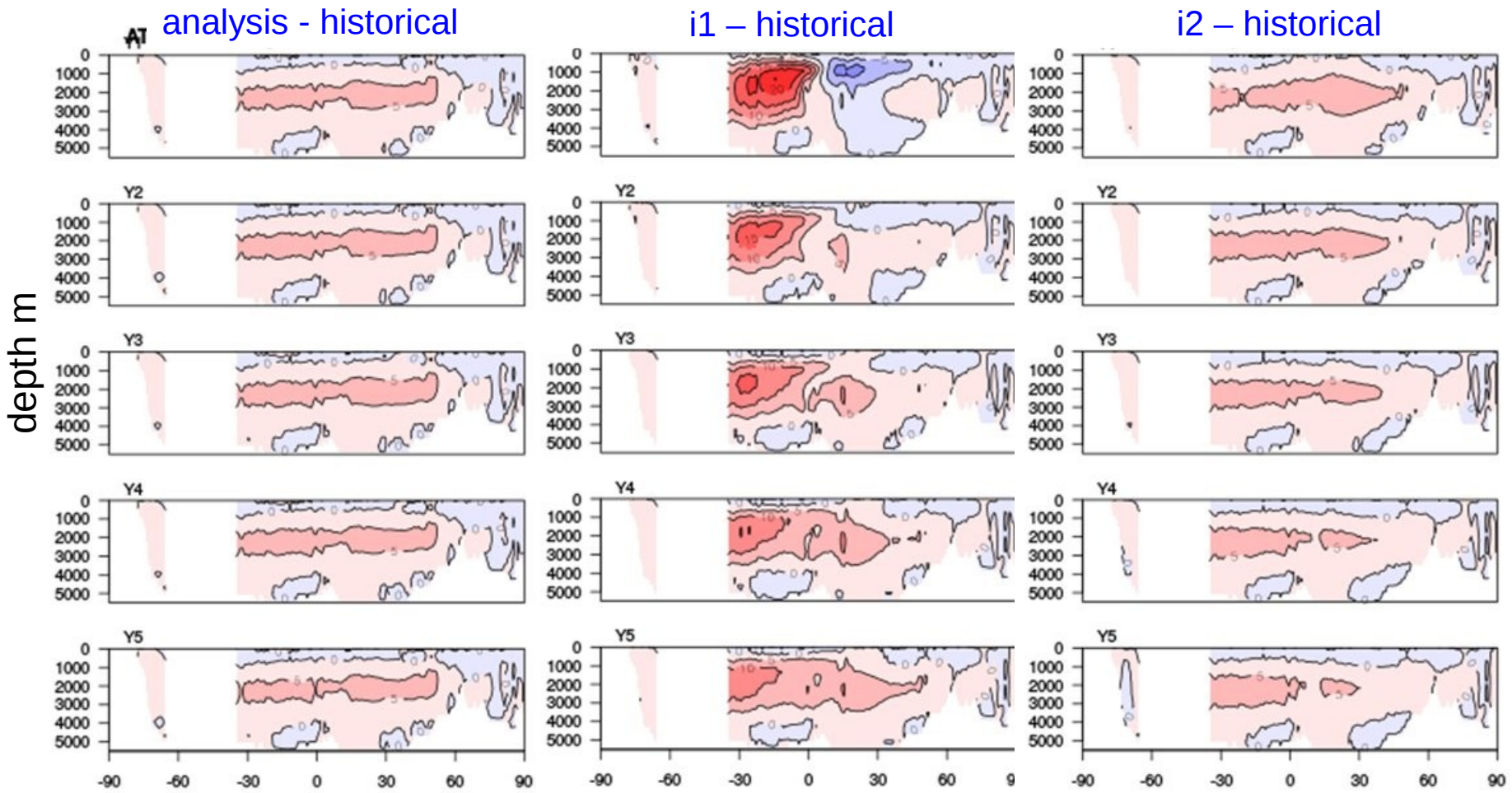


Evolution of SST decadal forecast climatology along equatorial Pacific for 1 model initialized two different ways



Another comparison between CanCM4 i1 vs i2 intializations

- Evolution of Atlantic meridional overturning: differences from historical
- Decadal forecasts initialized in January 1961,1966…2006
- CanCM4 assimilating analysis (used for initialization of seasonal/decadal forecasts), i1 and i2-initialized hindcasts



Summary

- The **aims** of the Long-Range Forecast Transient Intercomparison Project are to
  - Develop an online archive of climatologies for initialized hindcasts (and for initial conditions and historical simulations when available) for many sub-seasonal, seasonal and decadal forecast models
  - Develop a standard set of diagnostics for describing shock and drift phenomena in initialized climate forecasts
  - Facilitate investigations of the nature of forecast shock/drift in relation to initialization techniques employed and impacts of forecast quality

- **Community input is welcome and indeed solicited**, including
  - Suggestions for shock/drift diagnostics
  - Data contributions for models and/or initialization methods not in archive

- LRFTIP **data guide** is available at

  ftp://dapp2p.cccma.ec.gc.ca/pub/goapp/LRFTIP/LRFTIP_Data_v1.4.pdf

- Status of forthcoming data & diagnostics also will be posted

Atmosphere 2D (CMOR Tables day, Amon) - 1

Variable name	Description	CF Standard Name	unit	realm	freq	pri- ority
clt	Total Cloud Fraction	cloud_area_fraction	%	atmos	d,m,y	1
evspsbl	Evaporation	water_evaporation_flux	kg m-2 s-1	atmos	d,m,y	2
hfss	Surface Upward Sensible Heat Flux	surface_upward_sensible_heat_flux	W m-2	atmos	d,m,y	1
hfls	Surface Upward Latent Heat Flux	surface_upward_latent_heat_flux	W m-2	atmos	d,m,y	1
huss	Near-Surface Specific Humidity	specific_humidity	1	atmos	d,m,y	2
pr	Precipitation	precipitation_flux	kg m-2 s-1	atmos	d,m,y	1
psl	Sea Level Pressure	air_pressure_at_sea_level	Pa	atmos	d,m,y	1
rlds	Surface Downwelling Longwave Radiation	surface_downwelling_longwave_flux_in_air	W m-2	atmos	d,m,y	1*
rlus	Surface Upwelling Longwave Radiation	surface_upwelling_longwave_flux_in_air	W m-2	atmos	d,m,y	1*
rlut	TOA Outgoing Longwave Radiation	toa_outgoing_longwave_flux	W m-2	atmos	d,m,y	1**
rsds	Surface Downwelling Shortwave Radiation	surface_downwelling_shortwave_flux_in_air	W m-2	atmos	d,m,y	1*
rsdt	TOA Incident Shortwave Radiation	toa_incoming_shortwave_flux	W m-2	atmos	d,m,y	1**
rsut	TOA Outgoing Shortwave Radiation	toa_outgoing_shortwave_flux	W m-2	atmos	d,m,y	1**

Atmosphere 2D (CMOR Tables day, Amon) - 2

rsus	Surface Upwelling Shortwave Radiation	surface_upwelling_shortwave_flux_in_air	W m-2	atmos	d,m,y	1*
tas	Near-Surface Air Temperature	air_temperature	K	atmos	d,m,y	1
tasmax	Daily Maximum Near-Surface Air Temperature	air_temperature	K	atmos	d,m,y	2
tasmin	Daily Minimum Near-Surface Air Temperature	air_temperature	K	atmos	d,m,y	2
tauu	Surface Downward Eastward Wind Stress	surface_downward_eastward_stress	Pa	atmos	d,m,y	1
tauv	Surface Downward Northward Wind Stress	surface_downward_northward_stress	Pa	atmos	d,m,y	1
ts	Surface Temperature	surface_temperature	K	atmos	d,m,y	1
uas	Eastward Near-Surface Wind	eastward_wind	m s-1	atmos	d,m,y	2
vas	Northward Near-Surface Wind	northward_wind	m s-1	atmos	d,m,y	2

Atmosphere 3D (CMOR Tables day, Amon)

Variable name	Description	CF Standard Name	unit	realm	freq	pri-ority
hus	Specific Humidity	specific_humidity	1	atmos	d,m,y	1
ta	Air Temperature	air_temperature	K	atmos	d,m,y	1
ua	Eastward Wind	eastward_wind	m s-1	atmos	d,m,y	1
va	Northward Wind	northward_wind	m s-1	atmos	d,m,y	1

Ocean 2D (CMOR Tables day, Omon)

Variable name	Description	CF Standard Name	unit	realm	freq	pri-ority
hc300*	upper 300m heat content	heat_content_to_300m_depth	K	ocean	d, m,y	2
mlotst	Ocean Mixed Layer Thickness Defined by Sigma T	ocean_mixed_layer_thickness_defined_by_sigma_t	m	ocean	m,y	1
msftbarot	Ocean Barotropic Mass Streamfunction	ocean_barotropic_mass_streamfunction	kg s-1	ocean	m,y	1
msftmyzv***	Ocean Meridional Overturning Volume Streamfunction	ocean_meridional_overturning_volume_streamfunction	m3 s-1	ocean	m,y	2
sos	Sea Surface Salinity	sea_surface_salinity	psu	ocean	m,y	1
t20d*	20 degree isotherm depth	ocean_20_degree_isotherm_depth	m	ocean	d, m,y	2
thetaoeq**	Equatorial cross section of sea water potential temperature	equatorial_sea_water_potential_temperature	K	ocean	d,m,y	2
tos	Sea Surface Temperature	sea_surface_temperature	K	ocean	d,m,y	1
zos	Sea Surface Height Above Geoid	sea_surface_height_above_geoid	m	ocean	m,y	1

Ocean 3D (CMOR Table Omon)

Variable name	Description	CF Standard Name	unit	realm	freq	pri-ority
so	Sea Water Salinity	sea_water_salinity	psu	ocean	m,y	1
thetao	Sea Water Potential Temperature	sea_water_potential_temperature	K	ocean	m,y	1
uo	Sea Water X Velocity	sea_water_x_velocity	m s-1	ocean	m,y	1
vo	Sea Water Y Velocity	sea_water_y_velocity	m s-1	ocean	m,y	1
wo	Upward Ocean Velocity	upward_ocean_velocity	m s-1	ocean	m,y	1

Land (CMOR Tables Lmon, LImon)

Variable name	Description	CF Standard Name	unit	realm	freq	pri-ority
mofso	Soil Frozen Water Content	soil_frozen_water_content	kg m-2	land	m,y	2
mrso	Total Soil Moisture Content	soil_moisture_content	kg m-2	land	m,y	1*
mrsov	Total Volumetric Soil Moisture (Liquid and Solid) Content	volume_fraction_of_water_in_soil	1	land	m,y	1*
snw	Surface Snow Amount	surface_snow_amount	kg m-2	land	m,y	1

Sea Ice (CMOR Table OImon)

Variable name	Description	CF Standard Name	unit	realm	freq	pri-ority
sic	Sea Ice Area Fraction	sea_ice_area_fraction	%	seaIce	m,y	1
sit	Sea Ice Thickness	sea_ice_thickness	m	seaIce	m,y	1

Time-Invariant Fields (CMOR Table fx)

Variable name	Description	CF Standard Name	unit	realm	dimensionality	pri-ority
areacella	Atmosphere Grid-Cell Area	cell_area	m2	atmos	xy	1
sftlf	Land Area Fraction	land_area_fraction	%	atmos	xy	1
mrsofc	Capacity of Soil to Store Water	soil_moisture_content_at_field_capacity	kg m-2	land	xy	2
areacello	Ocean Grid-Cell Area	cell_area	m2	ocean	xy	1
basin	Region Selection Index*	region	1	ocean	xy	1
deptho	Sea Floor Depth	sea_floor_depth_below_geoid	m	ocean	xy	1
thkcello	Ocean Model Cell Thickness	cell_thickness	m	ocean	z	2