WCRP World Climate Research Programme

WORLD METEOROLOGICAL ORGANIZATION

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

International Science Council

Shocks and drifts: WGSIP's Long-Range Forecast Transient Intercomparison Project

Bill Merryfield[1], Mikhail Tolstykh[2], Woosung Lee[1]

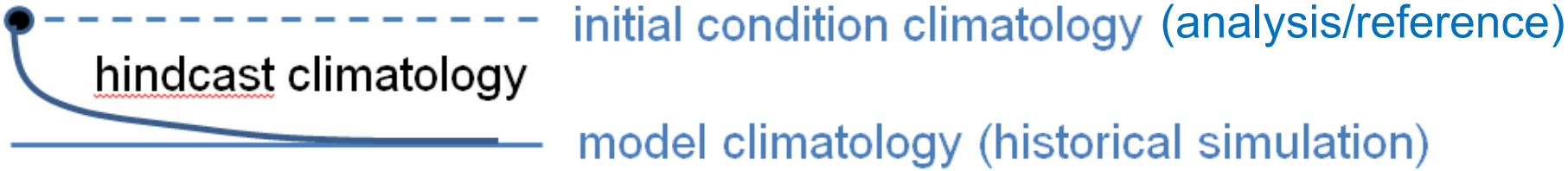
[1] ECCC/CCCma, [2] INM/RAS

Objectives

1) Develop a **multi-model online archive** of hindcast climatologies and related diagnostics including systems contributing to S2S, CHFP, DCPP

2) Develop **standard diagnostics** characterizing forecast shock/drift

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



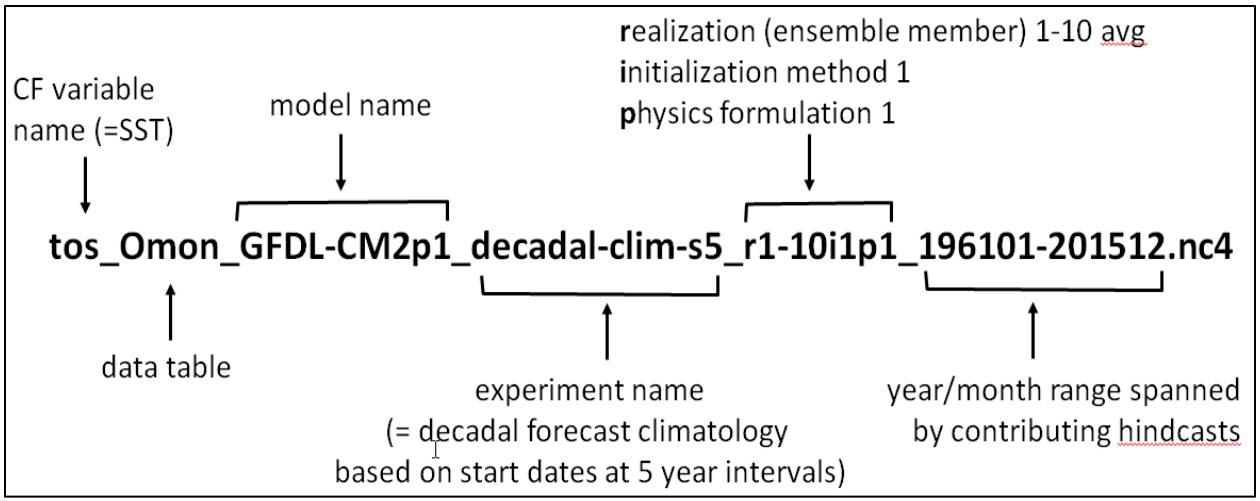
Currently:

- **4 subseasonal forecast models** (S2S)
- **19 seasonal forecast models** (CHFP, ENSEMBLES)
- **15 decadal forecast models** (CMIP5, ENSEMBLES)
- **Daily/monthly/annual data, many variables**

Data archive

Data format

- CF-compliant **NetCDF4**
- Time variable=**leadtime**
- File names, directory tree guided by **CMIP/ESGF conventions** →



Data location:

Directory: ftp://dapp2p.cccma.ec.gc.ca/pub/goapp/LRFTIP//

Directory Content:

250 Directory successfully changed.

Parent Directory (Root Directory)		
DECADAL	Jan 16 2017	
LRFTIP_Data_Specifications_current_version.pdf	Apr 28 2017	173k
LRFTIP_Data_v1.4.pdf	May 05 2016	173k
SEASONAL	Dec 09 2016	
SUBSEASONAL	Jan 05 2017	

- Can be located on WCRP project page via search, *migrating to new URL*

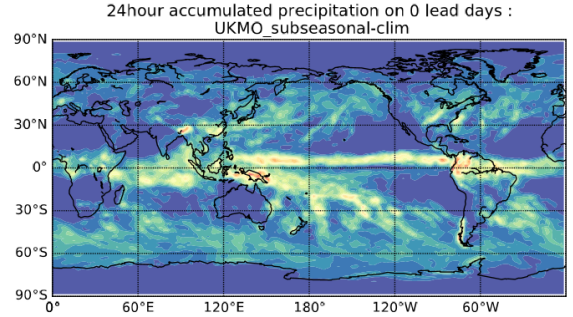
What's new

- Most recent effort has focused on developing diagnostics
- For each time scale have directories for data and diagnostics, containing python plotting scripts and (soon) plots for each model:

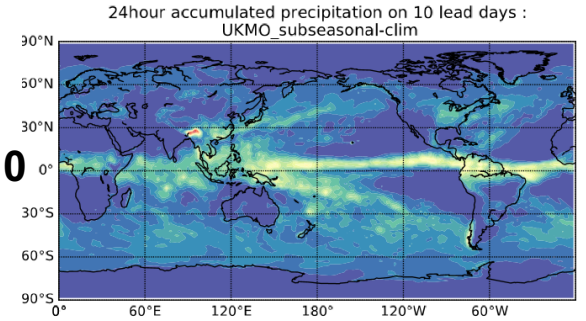
ftp://dapp2p.cccma.ec.gc.ca/pub/goapp/LRFTIP/DECADAL/diag/

Parent Directory (Root Directory)		
decadal_2D_diff_ocean.py	Mar 15 2018	9k
decadal_2D_hovmoller_ocean.py	Mar 15 2018	9k
decadal_2D_ocean_1model.py	Mar 15 2018	8k
decadal_2D_ocean_2model.py	Mar 15 2018	9k
decadal_3D_diff_ocean.py	Mar 15 2018	7k
decadal_3D_hovmoller_ocean.py	Mar 15 2018	9k
decadal_3D_longitude_depth_ocean.py	Mar 15 2018	10k
decadal_3D_ocean_1model.py	Mar 15 2018	6k
decadal_3D_ocean_2model.py	Mar 15 2018	7k
plot_Omon.sh	Mar 15 2018	47k

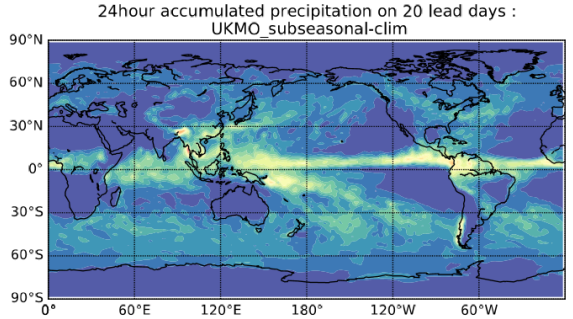
day 1

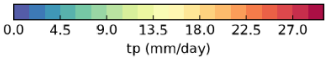


day 10



day 20

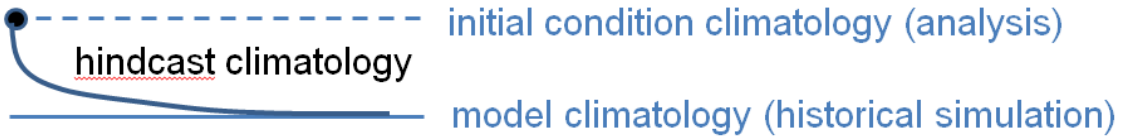




Climatological rain fall in UKMO S2S model initialized May 1 → (note "rain out") in day 1

Forward-looking questions

- **CMIP6:** DCPP decadal models will be added → data request includes runs used to initialize models →



- **Diagnostics:** to be "filled out" including important diagnostics in literature and accommodating suggestions/requests
- **Uptake:** Interest expressed by WGNE, APPLICATE…, but so far little or no external use of archive
- **What is missing?**
  - Publicity? Several conference/workshop presentations + EOS article, so existence as a resource shouldn't be completely unknown
  - Interest in shock/drift problem? Not likely, since has been and will continue to be one of key issues in climate modelling, and "Transpose CMIP" has long been conceptualized
  - For now keep at it and perhaps one or two publications intercomparing interesting diagnostics will help
- **Assessment proposed by TPOS2020** (to be discussed Friday): would contribute to model bias component

Extra slides

Current Status - Subseasonal

Variables: Number of variables for each model, climate system component, and averaging interval are shown in tables

Reference Forecasts

Subseasonal Model	Atmosphere Daily		Ocean Daily	
ECMWF-S2S	7	7	1	1
JMA-S2S	2	2	1	1
NCEP-S2S	7	7	1	1
UKMO-S2S	1	1	1	1

S2S data processed by Mikhail Tolstykh and Tatiana Krasjuk, INM-RAS

Current Status - Seasonal

Reference Forecasts

Seasonal Model	Atmosphere Daily		Atmosphere Monthly		Ocean Monthly		Land Monthly	Sea Ice Monthly	
CanCM3	18	22	22	22	12	12	4	1	2
CanCM4	18	22	22	22	12	12	4	1	2
ECMWF-S4			18	20			1		
JMAMRI-CGCM1	12	16	20	20	6	7			
JMAMRI-CGCM2			19	21	6	6	13		13
MIROC5_v1.0	12	18	16	18	6	7			
MPI-ESM-LR			20	22					
POAMA p24a/b/c			12	13					
ARPEGE			7	7					
CFS_SHFP	3	3	8	7					
CMAM	3	5	7	7			10		10
GloSea4		1	7	7					
GloSea5		1	7	7					
ENSEMBLES (CMCC-INGV, ECMWF-S3, IFM-GEOMAR, MF, DePreSys, HadGEM2	16	20	20	20			1		

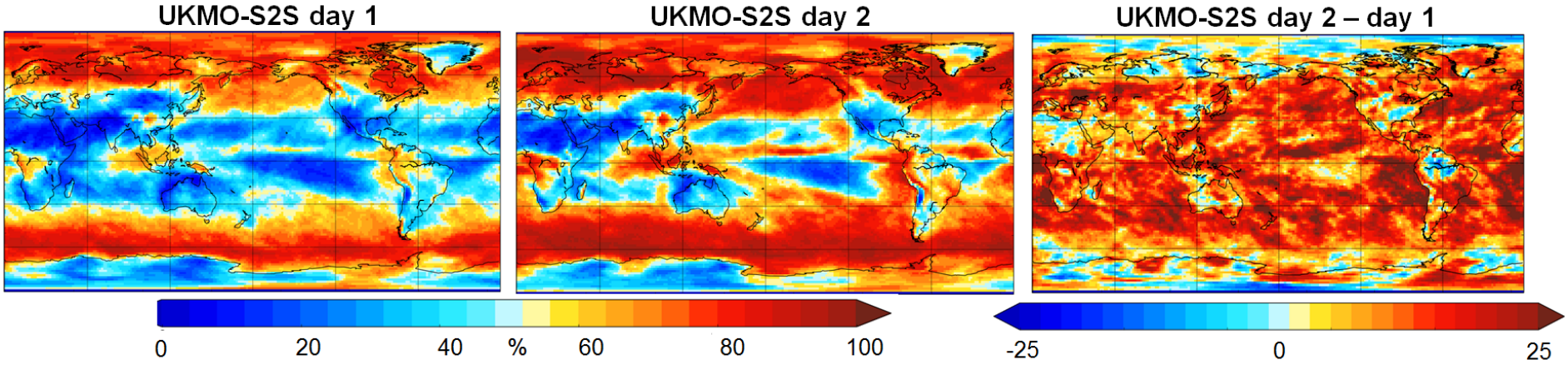
Current Status - Decadal

Analysis / Initial Conditions | Forecasts | Historical Simulations

Decadal Model	Atmosphere Daily	Atmosphere Monthly	Atmosphere Yearly	Ocean Monthly	Ocean Yearly	Land Month/yearly	Sealce Month/Yearly
CCSM4 (i1,i2)		24 24	24 24	8 9	8 9	3 3	2 2
MF-ENSEMBLES		20	20	11	11	1	
CFSv2(i1,i2)		26	26	7	7	1	2
CanCM4 (i1,i2)	25 16 6	25 26 17	25 26 17	13 13 13	13 13 13	4 3 2	2 2 2
CNRM-CM5	6 6	26 26	26 26	10 10	10 10	3 3	2 2
ECMWF-ENSEMBLES		20	20	11	11	1	
GFDL-CM2p1		18 18	18 18	11 11	11 11	2 2	2 2
HadCM3	9 9	25 25	25 25	6 6	6 6	3 3	2 2
IFM-ENSEMBLES		20	20	11	11	1	
MIROC5	20 20	26 26	26 26	7	7	3 3	2 2
MRI-CGCM3	6	26	26	10	10	3	2
UKMO-DePreSys-ENS		20	20			1	
UKMO-HadGEM2-ENS		20	20			1	
EC-EARTH		19 17	19 17	7 3	7 3		2 2
BCC-CSM1.1	6 6	26 26	26 26	7 7	7 7		2 2
CNRM-CM5	6 6	26 26	26 26	10 10	7 7	3 3	2 2

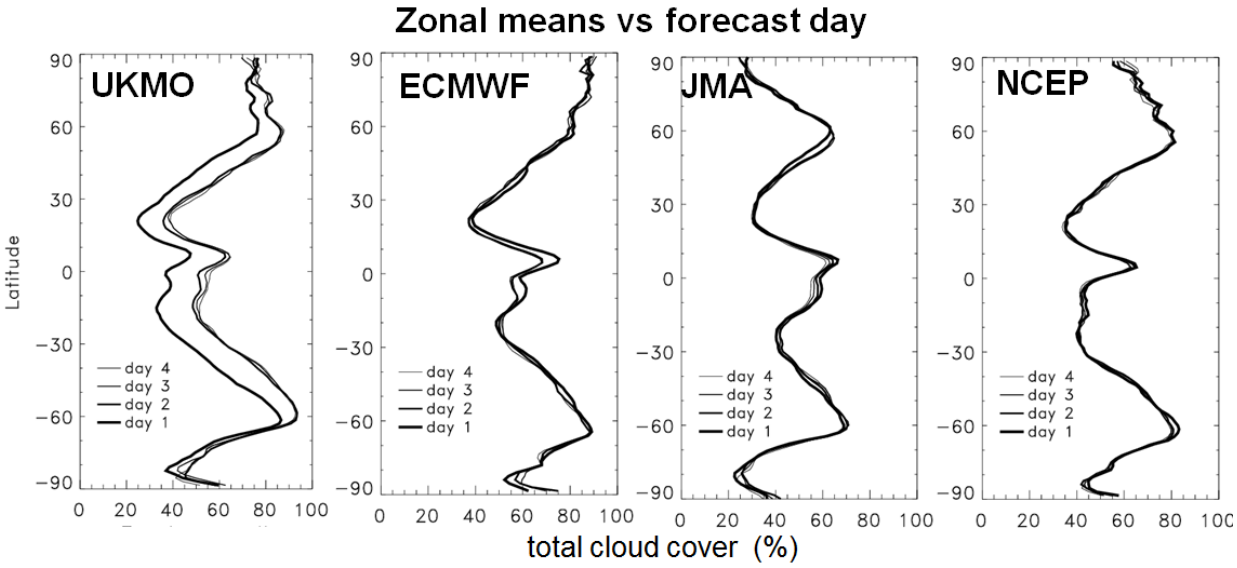
Sample Diagnostics - Subseasonal

- **Total cloud cover** in first days of hindcasts initialized near **1 Nov**



- UKMO model shows large transient relative to other models ↓

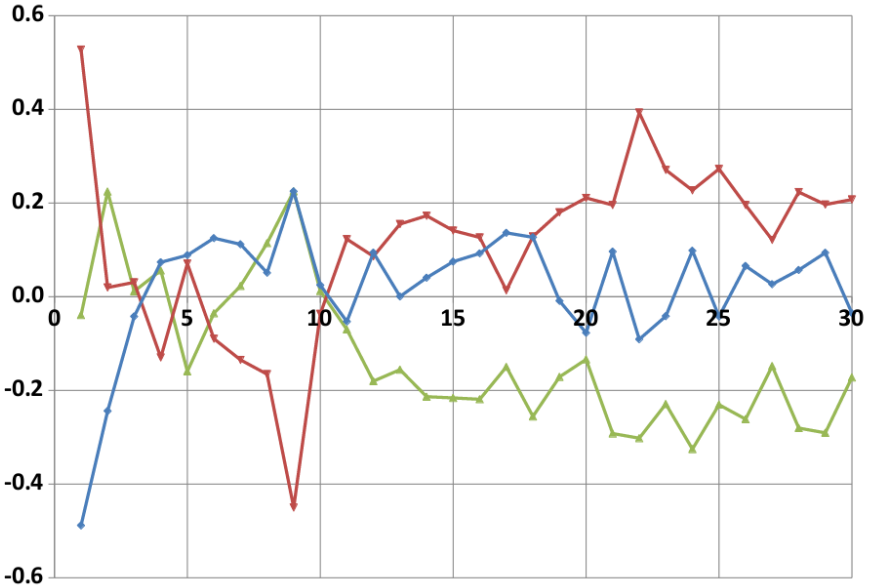
- Low initial cloud cover is a result of initializing UKMO model with ERA-Interim fields



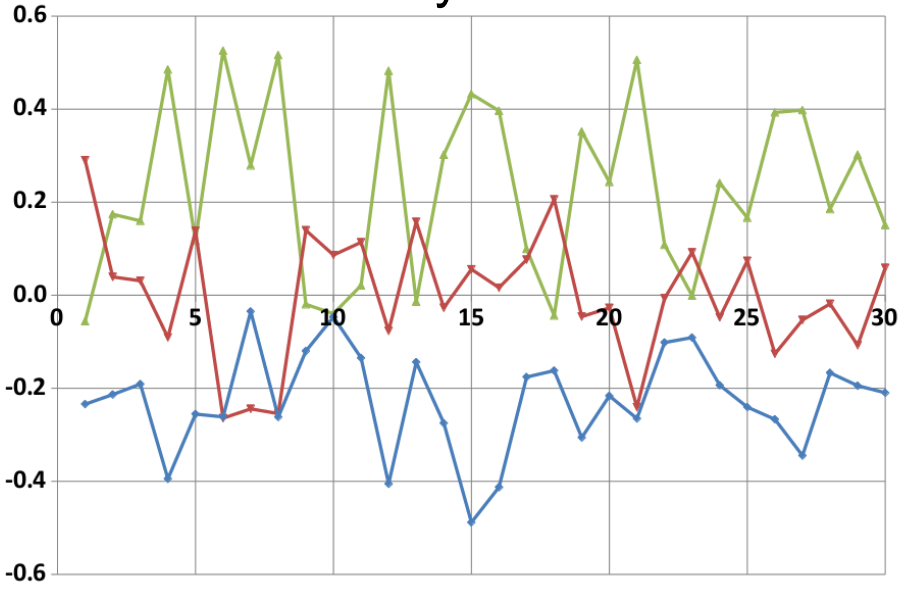
Sample Diagnostics - Subseasonal

- Daily precipitation minus GPCP reference climatology
- Averages over North Atlantic region

from 1 Nov 1999-2010



from 1 May 1999-2010

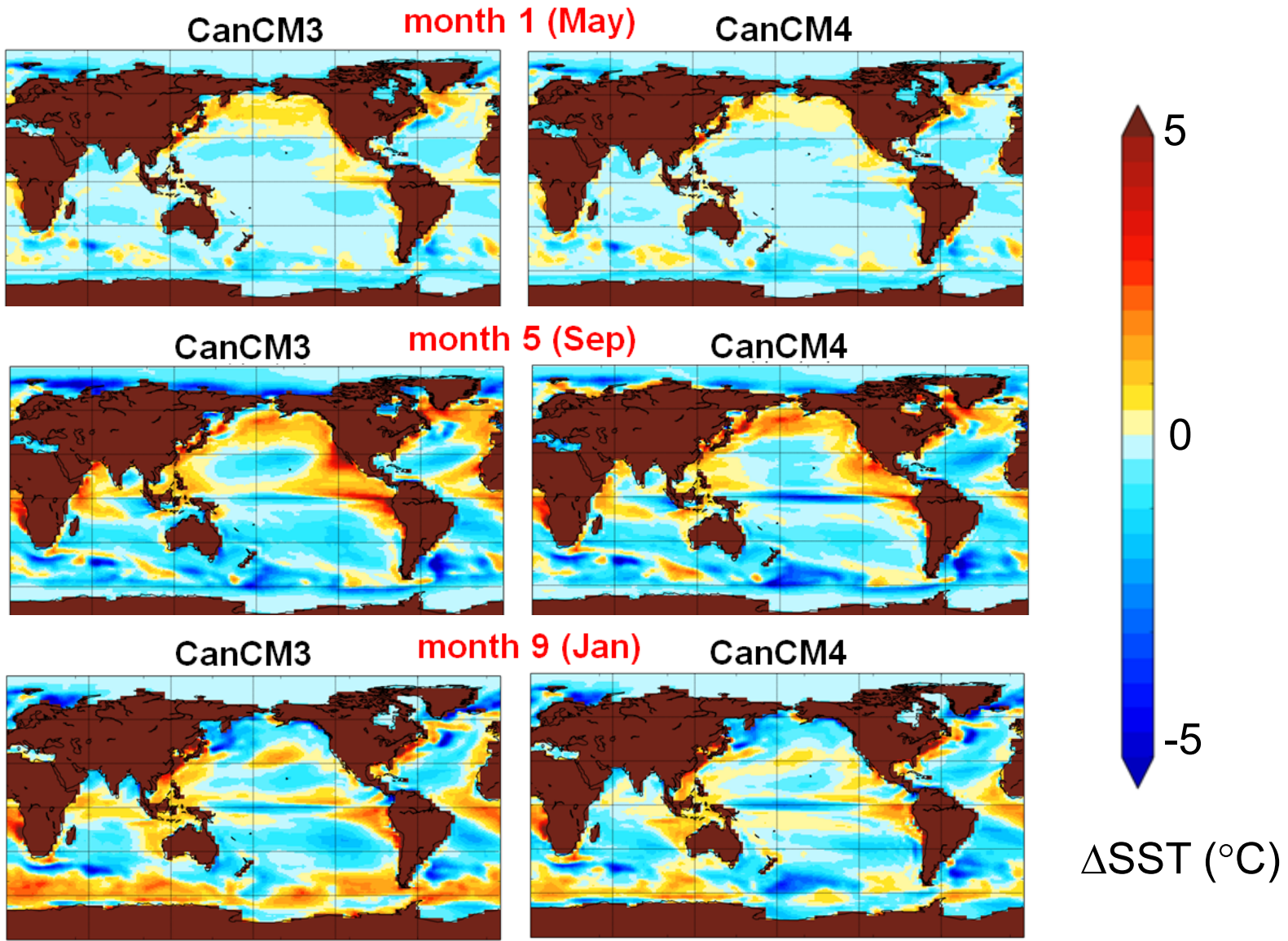


ECMWF UKMO NCEP

Plots courtesy of Mikhail Tolstykh

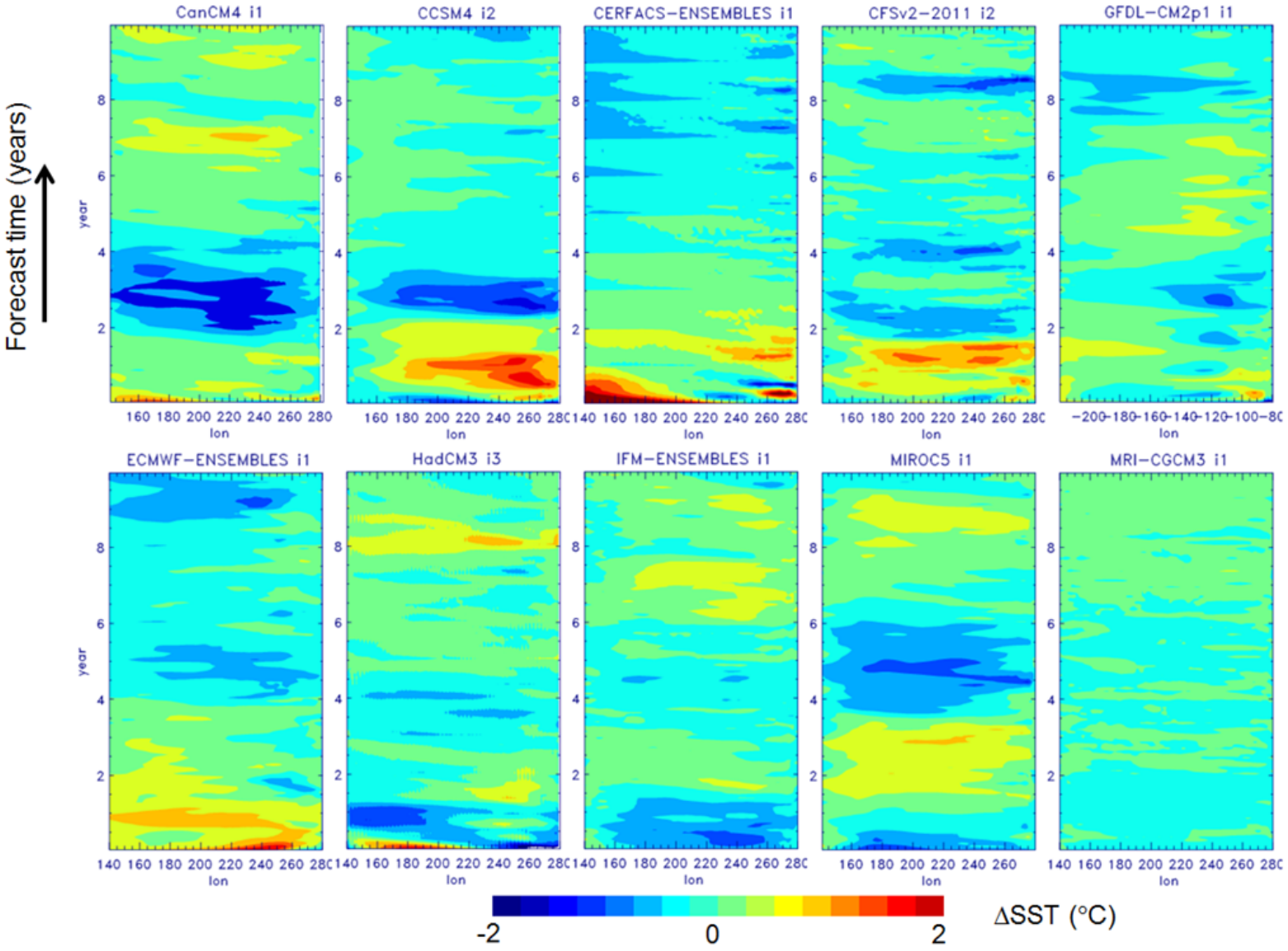
Sample Diagnostics - Seasonal

- **SST biases** developing in hindcasts initialized **1 May** in two models having same ocean, different atmospheric components (vs OISST reference)



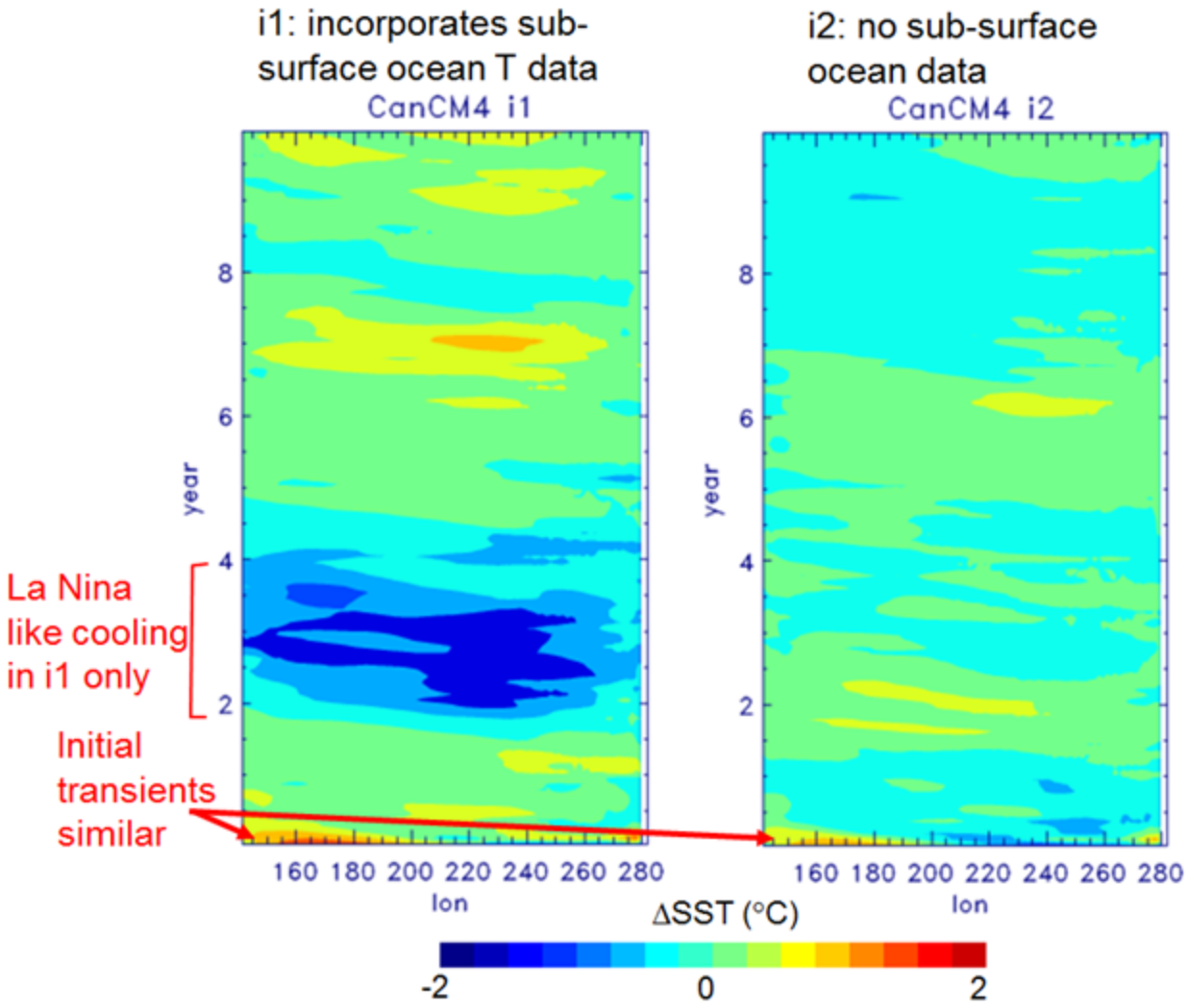
Sample Diagnostics - Decadal

- Drift evolution of SST across equatorial Pacific in 10 decadal prediction models, showing El Niño and La Niña-like transients



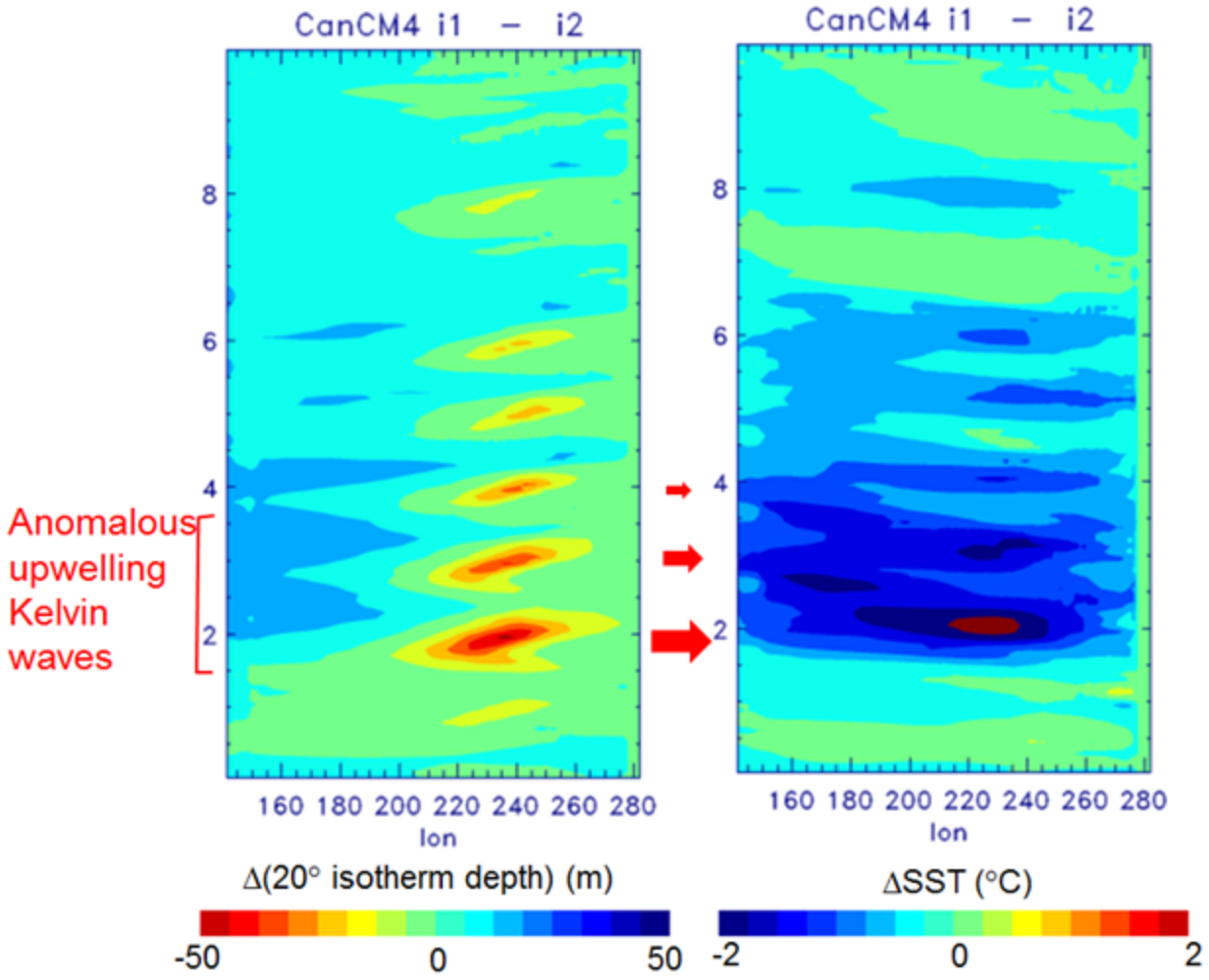
Sample Diagnostics - Decadal

- Same except for CanCM4 using two different ocean initialization methods: i1 includes subsurface data, i2 = surface initialization only



Sample Diagnostics - Decadal

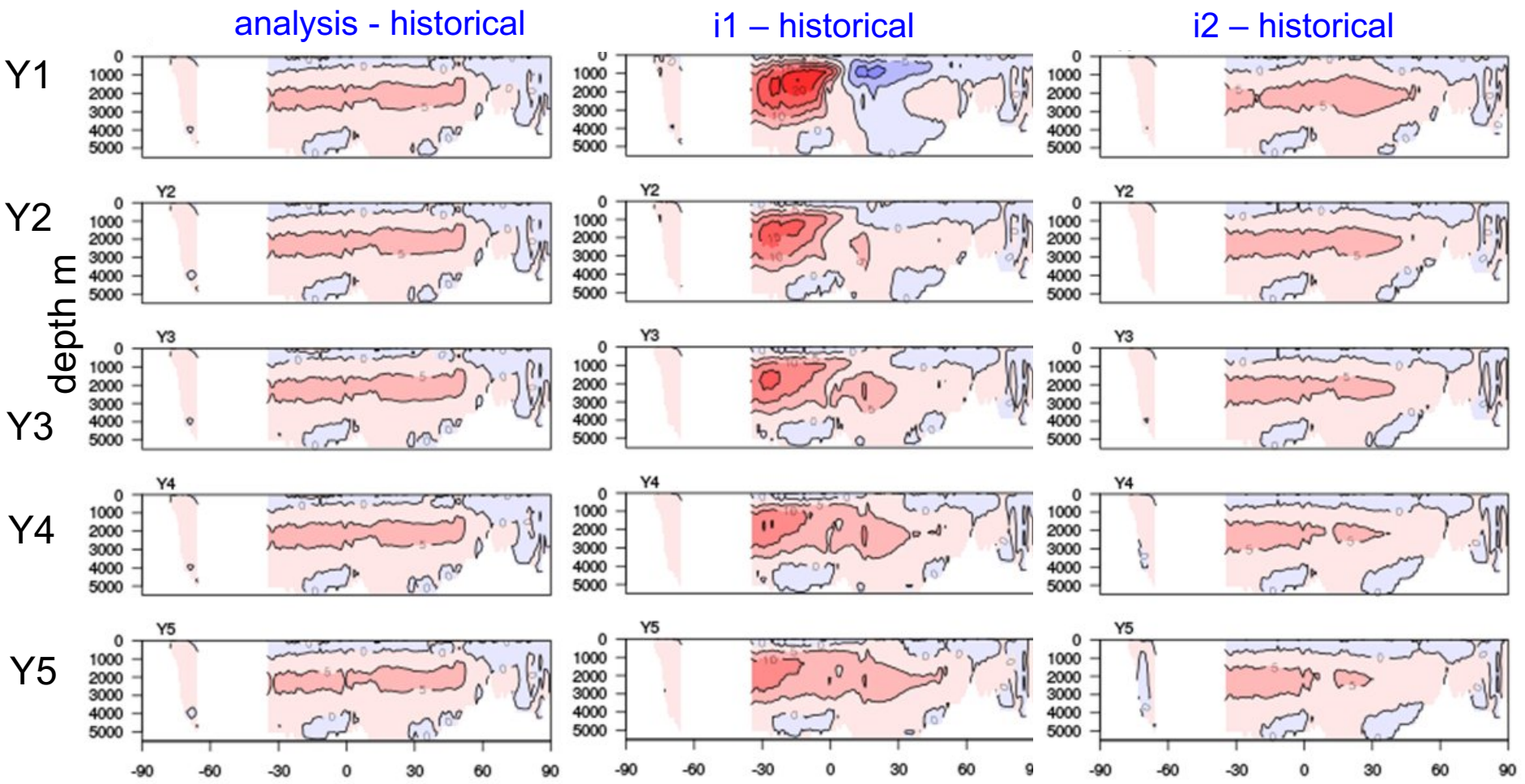
- *differences* (i1–i2) in 20°C isotherm depth (left) and SST (right), showing La Niña-like transient excitation by anomalous upwelling Kelvin waves in years 2-6



Sample Diagnostics - Decadal

Another comparison between CanCM4 i1 vs i2 intializations

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

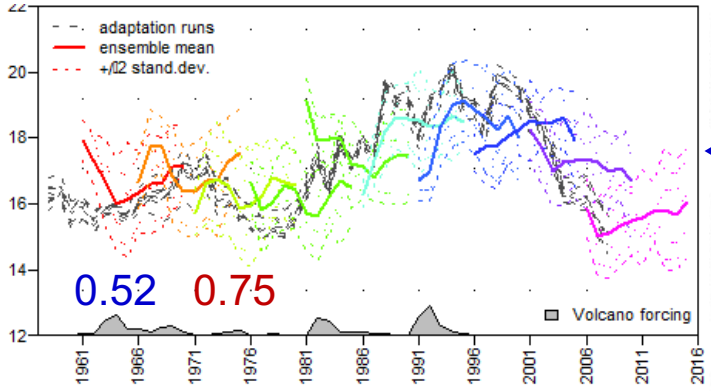


Sample Diagnostics - Decadal

Another comparison between CanCM4 i1 vs i2 intializations

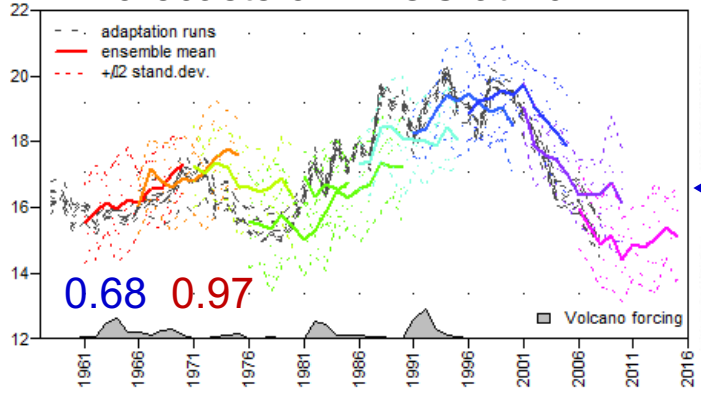
- Evolution of Atlantic meridional overturning: differences from historical in years 1-5
- CanCM4 assimilating analysis (used for initialization of seasonal/decadal forecasts), i1 and i2-initialized hindcasts

i1 forecasts of AMOC at 26°N



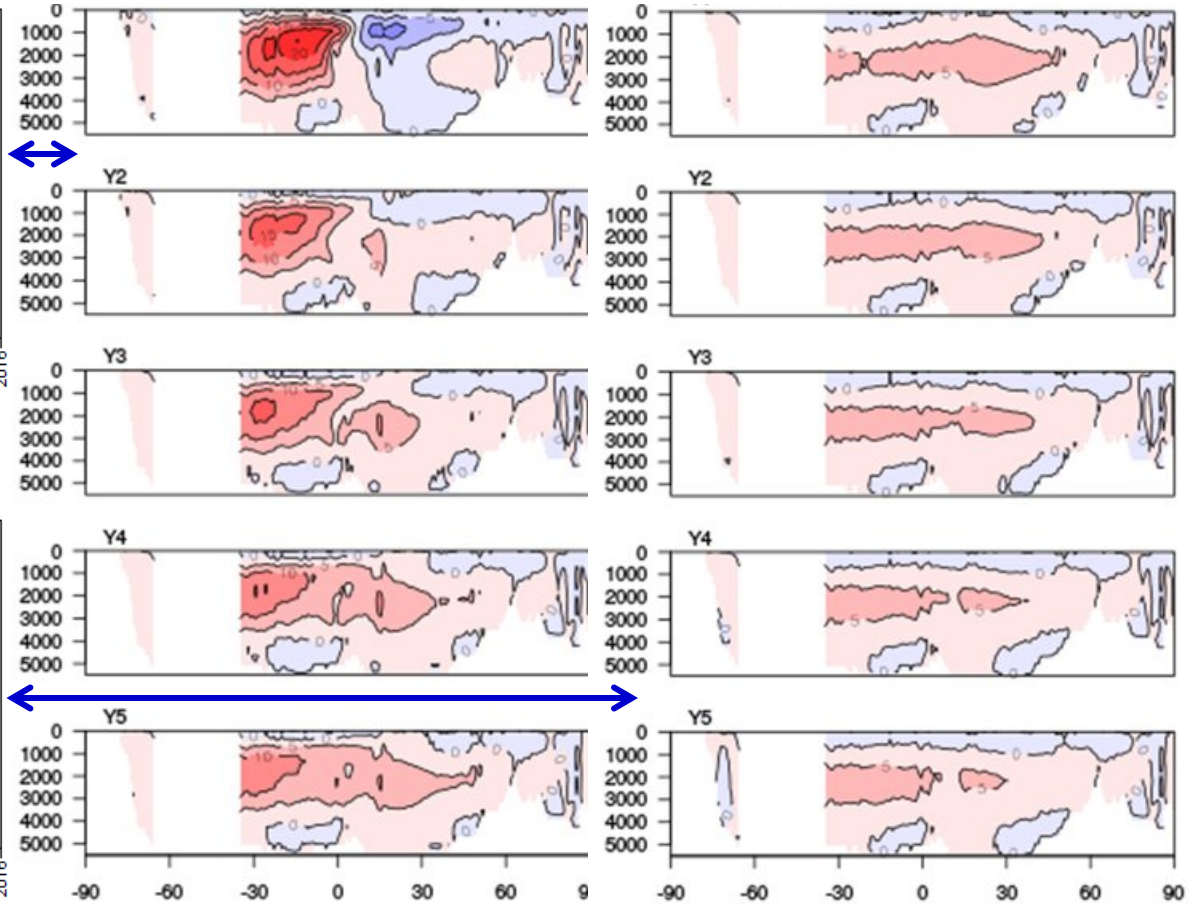
mean ACC in Y1-10 **ACC of Y1-10 mean**

i2 forecasts of AMOC at 26°N



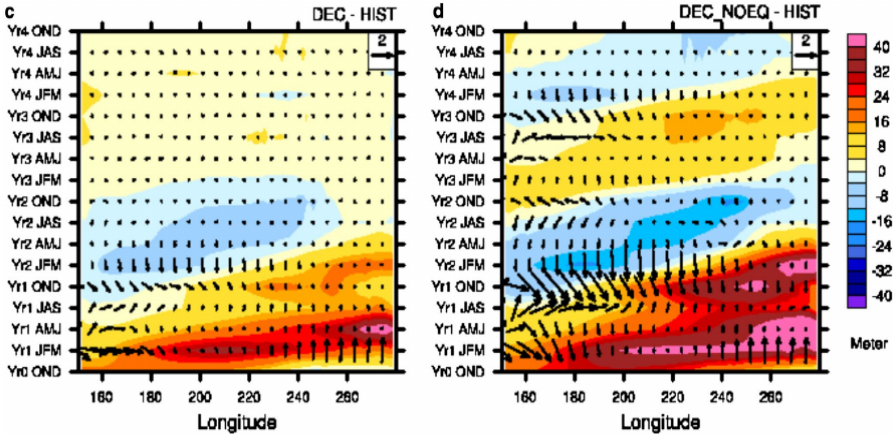
i1 – historical

i2 – historical

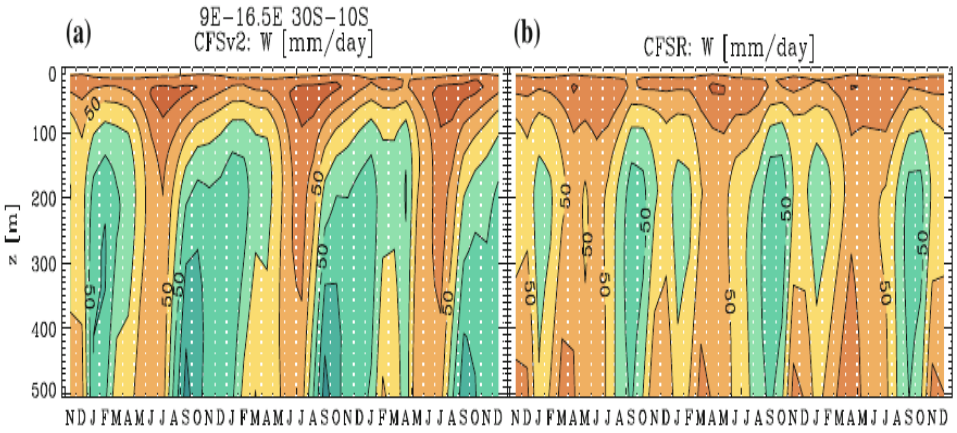


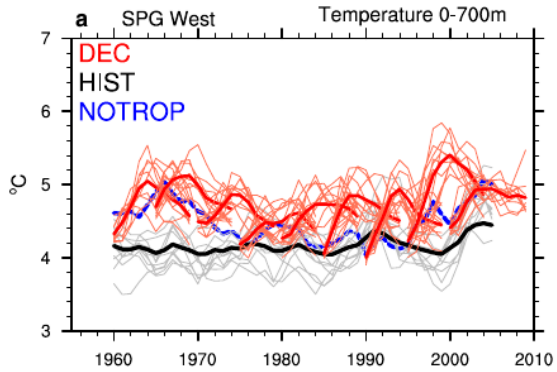
Some of the many hindcast climatology diagnostics examined in recent studies

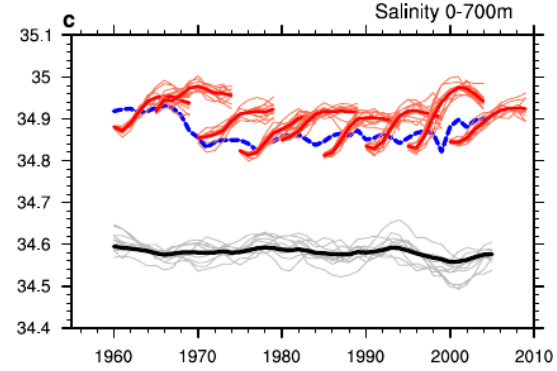
Sanchez-Gomez et al., *Clim. Dyn.*, 2015



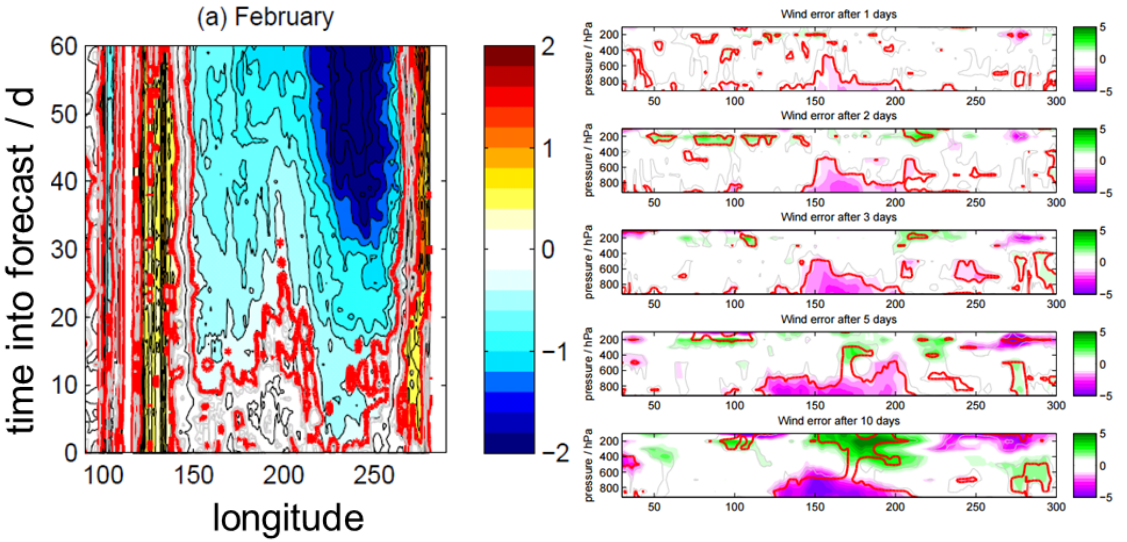
Toniazzo & Woolnough, *Clim. Dyn.*, 2014







Shonk, *Presentation at WGSIP 17,* 2015



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	%	sealce	m,y	1
sit	Sea Ice Thickness	sea_ice_thickness	m	sealce	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