UKESM Temperature profile mask

The purpose of this notebook is to create a mask to remove all land based data points and Nans at a depth of 2000 m from the UKESM temperature data from historic simulations. To do this the notebook takes imports a prior mask calculated in v1.0.

The mask calculation and creation can be found in the bottom half of the document.

TODO: Plot masks in orthographic projection.

Dask Import

In [1]:
```
from dask.distributed import Client

client = Client("tcp://127.0.0.1:42942")
client
```

Out[1]:

Client

Scheduler: tcp://127.0.0.1:42942
Dashboard: http://127.0.0.1:8787/status

Cluster

Workers: 9
Cores: 9
Memory: 57.98 GB

Choices for data

In [2]:
```
#Ocean Area data for averaging
areaActivityId = 'CMIP'
areaMemberId = "r1i1p1f2"
areaVariableId = 'volcello'
areaSourceId = 'UKESM1-0-LL'
areaDataSetNo = 0 #First database in results to be used

#Custom Variables
idSel = 0 #Run Id selection
maxLat = -30
maxLev = 2000
timeSel = slice("1980-01","2009-12")

exportMaskName = "OceanMaskVolcello"
```

Imports

In [3]:
```
import cartopy.crs as ccrs
import cartopy.feature as cfeature
import dask.dataframe as dd
import fsspec
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import xarray as xr
import zarr
```

```
from dask import config
from dask import delayed
from matplotlib.pyplot import cm
from math import isnan

config.set(**{'array.slicing.split_large_chunks': True})
print("Imports complete")
```

```
Imports complete
```

Accessing Dataset Database

In [4]:

```
df = pd.read_csv('https://storage.googleapis.com/cmip6/cmip6-zarr-consolidated-stores.csv'
print("Database accessed")
```

```
Database accessed
```

Filtering for relevant data sets

Ocean area data to be used for averaging

In [5]:

```
dfArea = df[df.activity_id.eq(areaActivityId) & df.variable_id.eq(areaVariableId) & df.sou
print(str(len(dfArea))+" datasets found.")
dfArea
```

```
1 datasets found.
```

Out[5]:

	activity_id	institution_id	source_id	experiment_id	member_id	table_id	variable_id	grid_label	
207913	CMIP	MOHC	UKESM1-0-LL	historical	r1i1p1f2	Omon	volcello	gn	gs://cmip6/

Opening all datafiles

Ocean Area data

In [6]:

```
dsArea = xr.open_zarr(fsspec.get_mapper(dfArea.zstore.values[areaDataSetNo]), consolidated
print("Ocean Area data loaded and stored in dsArea")
```

```
Ocean Area data loaded and stored in dsArea
```

Selection of Data

In [7]:

```
dataArea = dsArea.volcello.rename({"latitude":"lat", "longitude":"lon"})
dataAreaLatFilt = dataArea.where(dataArea.lat < maxLat, drop=True)
if True: #Taking 2000 m
    dataAreaLatLevFilt = dataAreaLatFilt.sel(lev = maxLev, method="nearest")
    dataAreaLatLevFiltT = dataAreaLatLevFilt.sel(time=timeSel)
    dataAreaLatLevFiltTM = dataAreaLatLevFiltT.mean("time", keep_attrs=True)
else: #Taking mean of 0 - 2000 m
    dataAreaLatLevFilt = dataAreaLatFilt.where(dataAreaLatFilt.lev < maxLev, drop=True)
    dataAreaLatLevMFilt = dataAreaLatLevFilt.mean("lev", keep_attrs=True)
    dataAreaLatLevMFiltT = dataAreaLatLevMFilt.sel(time=timeSel)
    #dataAreaLatLevMFiltTM = dataAreaLatLevMFiltT.mean("time", keep_attrs=True) #memory is
    #dataAreaLatLevMFiltTM = dataAreaLatLevMFiltTM.compute() #memory issues here
```

```
print("Finished data selection, volcello data filtered and stored in dataAreaLatLevFiltM.\
#dataAreaLatLevMFilt #Uncomment to see filtered volcello data set
```

```
Finished data selection, volcello data filtered and stored in dataAreaLatLevFiltM.
Unaveraged data is stored in dataAreaLatLevFilt.
```

Time identification

In [8]:

```
globalStartDate = dataAreaLatLevFiltT["time"][0].values
globalDateInc = dataAreaLatLevFiltT["time"][1].values - globalStartDate
globalEndDateIn = dataAreaLatLevFiltT["time"][-1].values
globalEndDateOut = globalEndDateIn + globalDateInc

globalStartDateStr = str(globalStartDate)[:7]
globalEndDateInStr = str(globalEndDateIn)[:7]
globalEndDateOutStr = str(globalEndDateOut)[:7]

print("Data start date: "+globalStartDateStr)
print("Data end date (included): "+str(globalEndDateInStr))
print("Data end date (excluded): "+str(globalEndDateOutStr))
print("Data increments in steps of "+str(globalDateInc))
```

```
Data start date: 1980-01
Data end date (included): 2009-12
Data end date (excluded): 2010-01
Data increments in steps of 30 days, 0:00:00
```

Calculation

Functions:

convertToOne - Takes an input data set and returns a same dimensioned data set with values (int) 1 for all non Nan values (maximum input value magnitude 10^14). Is a delayed type.

maskCalc - takes an input data set and returns a (int) 1 and "Nan" mask.

In [9]:

```
@delayed
def convertToOne(dataSet):
    '''Takes in given dataSet and returns values of (int) 1 for all non Nan values (10^14
    dataSetModify = dataSet.copy()
    dataSetModify.values = dataSetModify.values/100000000000000 + 1
    dataSetModify = dataSetModify.astype(int)
    return dataSetModify


def maskCalc(LocData):
    '''Takes in a given data set and returns a data set of (int) 1 and Nan matching initia
    mask = convertToOne(LocData)
    mask = mask.compute()
    maskNan = mask.where(mask.values == 1)
    return maskNan

print("Calculation functions defined")
```

```
Calculation functions defined
```

Plotting functions

Functions

mapPlot - plots the Southern Ocean orthographic project of the input data set, with input title and figure number

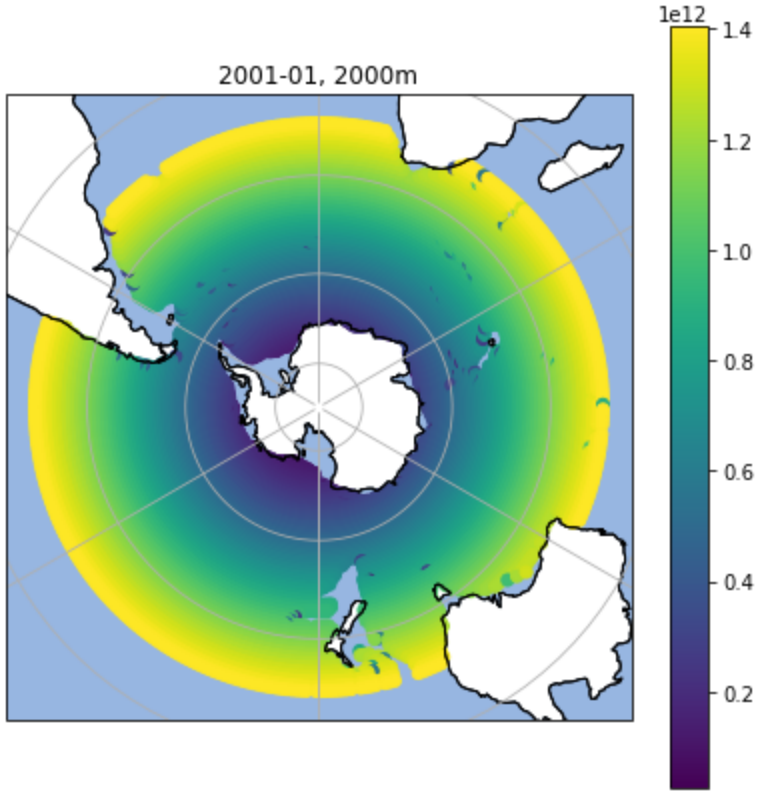
In [10]:

```
def mapPlot(dataSet, title, plotNo):
    '''Displays given data set on a map'''
    plt.figure(plotNo, figsize= (7,7))
    p=dataSet.plot(x='lon',y='lat',transform=ccrs.PlateCarree(),
        subplot_kws={'projection': ccrs.SouthPolarStereo()})
    p.axes.gridlines()
    p.axes.coastlines()
    plt.title(str(title))

def mapPlotij(dataSet, title, plotNo):
    '''Displays given data set on a map'''
    fig = plt.figure(plotNo, figsize= (7,7))
    ax = plt.axes(projection=ccrs.SouthPolarStereo())
    ax.add_feature(cfeature.OCEAN)
    ax.add_feature(cfeature.COASTLINE)
    ax.coastlines()
    ax.gridlines()
    im = plt.scatter(x=dataSet['lon'], y=dataSet['lat'], transform=ccrs.PlateCarree(), c=c
    cbar = fig.colorbar(im)
    plt.title(str(title))

def mapPlotScatter(dataSet, title, plotNo):
    '''Displays given data set on a map'''
    plt.figure(plotNo, figsize= (7,7))
    p=dataSet.scatter(x='lon',y='lat',transform=ccrs.PlateCarree(), c='values', cmap='bwr'
    p.axes.gridlines()
    p.axes.coastlines()
    plt.title(str(title))

def mapPlotScatterRec(dataSet, title, plotNo):
    '''Displays given data set on a map'''
    fig = plt.figure(plotNo, figsize= (20,10))
    im = plt.scatter(x=dataSet['lon'],y=dataSet['lat'], c=dataSet.values, cmap='bwr')
    cbar = fig.colorbar(im)
    plt.title(str(title))

print("Plotting functions defined")
```

```
Plotting functions defined
```

In [11]:

```
singleMonth = dataAreaLatLevFilt.sel(time="2001-01")
mapPlotij(singleMonth, "2001-01, 2000m", 1)
```



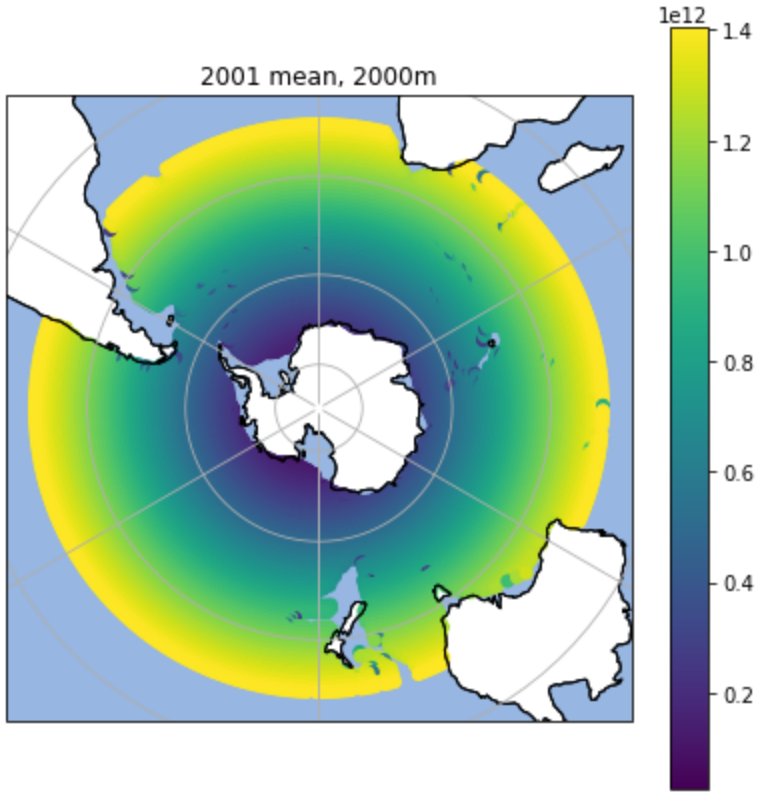
In [12]:

```
singleYearData = dataAreaLatLevFiltT.sel(time = slice("2001-01", "2001-12"))
singleYear = singleYearData.mean("time")
singleYear = singleYear.compute()
print("Single Year mean data calculated.")
```

```
Single Year mean data calculated.
```

In [13]:

```
mapPlotij(singleYear, "2001 mean, 2000m", 1)
```



Plot data of area and observe, generate mask

Calculating the mask

Creating the mask

Combining the filtered data with the imported mask

Calculating the mask

In [14]:
```
timeMaskLen = len(dataAreaLatLevFiltT["time"])
timeMask = np.zeros(timeMaskLen, dtype=bool)
timeMask[0] = True
timeMask[-1] = True
timeMask[int(timeMaskLen/2)] = True
sampleMaskData = dataAreaLatLevFiltT[timeMask]
sampleMaskData = sampleMaskData.mean("time", keep_attrs=True)
sampleMaskData = sampleMaskData.compute()
print("Volcello mask data calculated and stored in sampleMaskData.")
```

```
Volcello mask data calculated and stored in sampleMaskData.
```

In [15]:
```
maskVolcello = maskCalc(sampleMaskData)
print("Volcello mask calculated and stored in maskVolcello.")
```

```
Volcello mask calculated and stored in maskVolcello.
```

In [16]:
```
maskVolcelloRange = maskCalc(singleYearData)
print("Vocello Year mask calculated.")
```

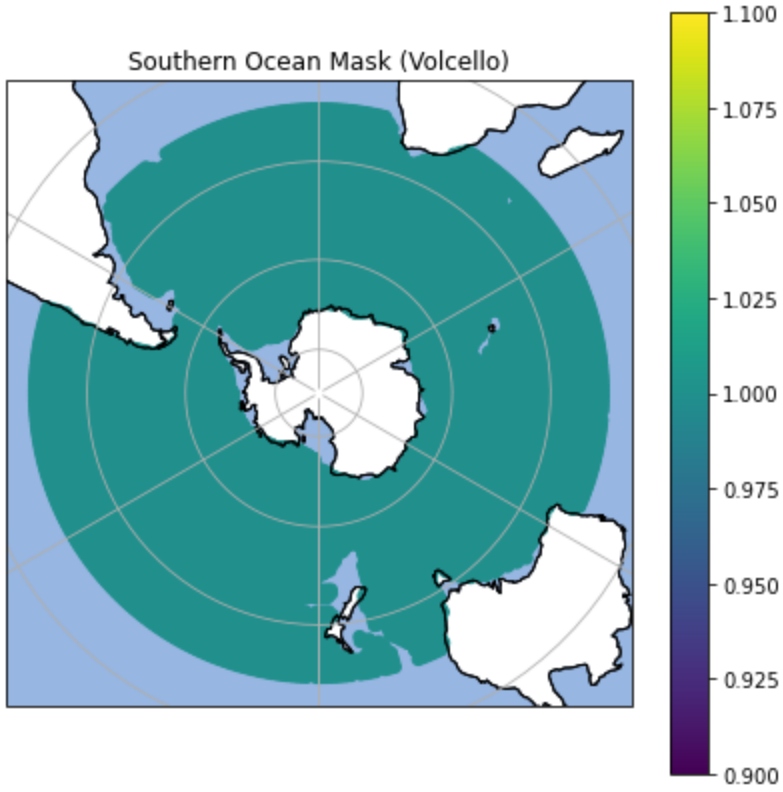
```
Vocello Year mask calculated.
```

In [17]:
```
SeasonalDiff = maskVolcelloRange.sel(time="2001-02") - maskVolcelloRange.sel(time="2001-08
print("Seasonal Difference in year mask calculated.")
```

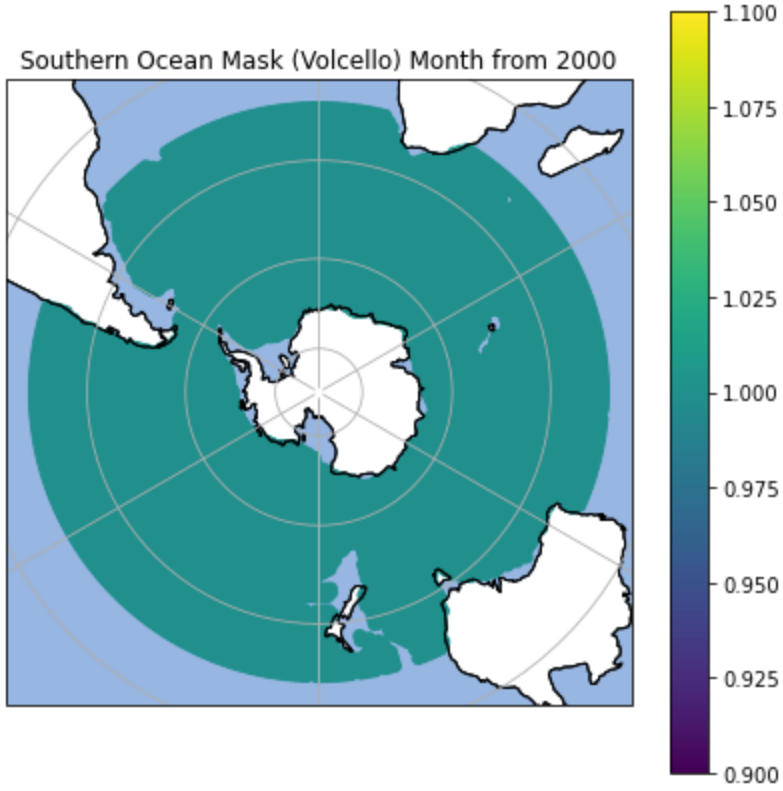
```
Seasonal Difference in year mask calculated.
```

Plotting volcello mask

In [18]:
```
mapPlotij(maskVolcello, "Southern Ocean Mask (Volcello)", 1)
```

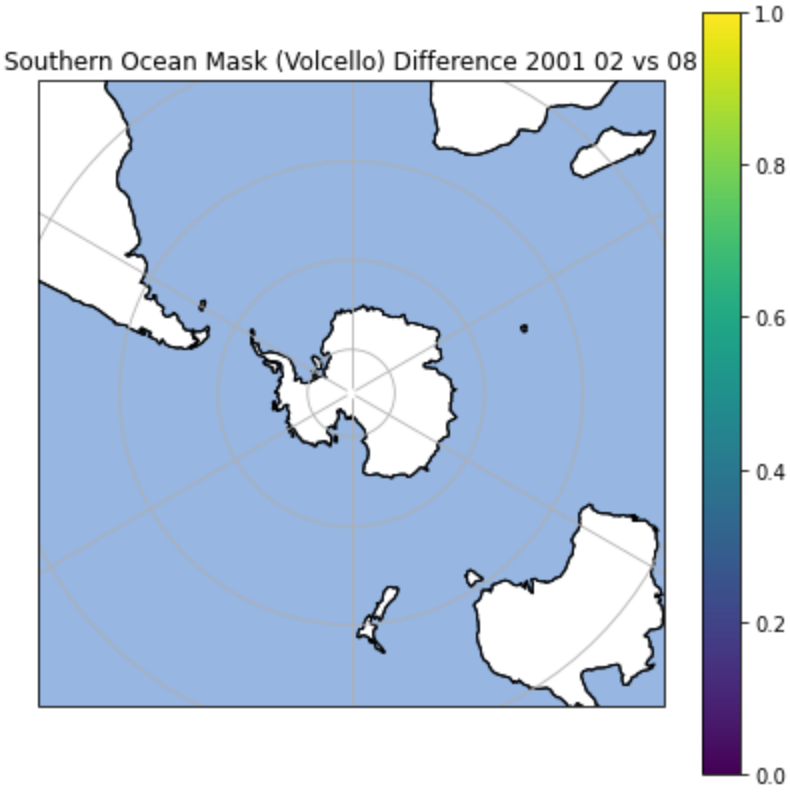


In [19]:
```
mapPlotij(maskVolcelloRange.sel(time="2001-04"), "Southern Ocean Mask (Volcello) Month fro
```



Mask comparison

In [20]:
```
mapPlotij(SeasonalDiff, "Southern Ocean Mask (Volcello) Difference 2001 02 vs 08", 1)
```



Saving and reloading the mask

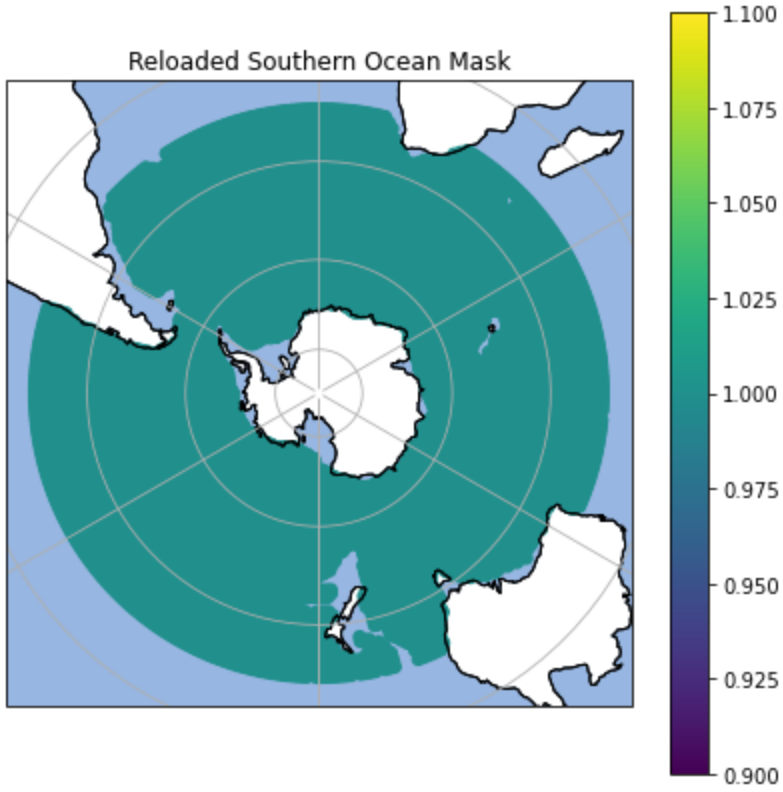
Saving the mask

In [21]:
```
maskVolcello.to_netcdf(exportMaskName)
print("Mask saved to "+exportMaskName+".")
```

```
Mask saved to OceanMaskVolcello.
```

Reloading the mask

In [22]:
```
maskFile = xr.open_dataset(exportMaskName)
oceanMaskReload = maskFile.to_array()
mapPlotij(oceanMaskReload, "Reloaded Southern Ocean Mask", 1)
```



Checking mask dimensions

In [23]:

```
print("Exported mask dims: ", maskVolcello.dims)
print("Loaded mask dims: ", oceanMaskReload.dims)
```

```
Exported mask dims:  ('j', 'i')
Loaded mask dims:  ('variable', 'j', 'i')
```