In [1]:
```
import os
print(os.environ['SSS_TAG_DIR'])
import iris
print(iris.__version__)
import numpy as np
```

```
/net/project/ukmo/scitools/opt_scitools/conda/deployments/default-2022_11
_22
3.3.1
```

In [2]:
```
# Original climatology
orig = iris.load_cube('/project/cma/clim/ecv_soil_moisture/ecv_soil_moist

# Fix units, since Iris doesn't like the formatting
if orig.attributes['invalid_units'] == 'm^3m^-3':
    orig.units = 'm3 m-3'
    del orig.attributes['invalid_units']

# Roll 180 degrees and flip N-S
nlon = len(orig.coord('longitude').points)
nlat = len(orig.coord('latitude').points)
orig.data = np.roll(orig.data, nlon // 2)
orig.coord('longitude').points = orig.coord('longitude').points + 180

orig.data = np.flip(orig.data, 0)
orig.coord('latitude').points = np.flip(orig.coord('latitude').points)

print(orig)
print(orig.coord('longitude'))
print(orig.coord('latitude'))
```

```
moisture_content_of_soil_layer / (m3 m-3) (latitude: 720; longitude: 144
0)
    Dimension coordinates:
        latitude                                x               -
        longitude                               -               x
    Attributes:
        CDI                                 'Climate Data Interface version
1.6.1 (http://code.zmaw.de/projects/cdi ...'
        CDO                                 'Climate Data Operators version
1.6.1 (http://code.zmaw.de/projects/cdo ...'
        Conventions                         'CF-1.4'
        history                             'Fri Jan 31 11:47:12 2014: cdo
chname,ECV_Soil_Moisture_10year_Climatology,moisture_content_of_soil_laye
r ...'
        longname                            'Soil Moisture'
        production                          '1999-2008 Seasonal mean from E
SA ECV Soil Moisture Data'
DimCoord :  longitude / (degrees)
    points: [2.5000e-01, 5.0000e-01, ..., 3.5975e+02, 3.6000e+02]
    shape: (1440,)
    dtype: float32
    standard_name: 'longitude'
    long_name: 'longitude'
    var_name: 'lon'
DimCoord :  latitude / (degrees)
    points: [-90.  , -89.75, ...,  89.5 ,  89.75]
    shape: (720,)
    dtype: float32
    standard_name: 'latitude'
    long_name: 'latitude'
    var_name: 'lat'
```

```
/opt/scitools/conda/deployments/default-2022_11_22/lib/python3.9/site-pac
kages/iris/fileformats/_nc_load_rules/helpers.py:659: UserWarning: Ignori
ng netCDF variable 'moisture_content_of_soil_layer' invalid units 'm^3m^-
3'
  warnings.warn(msg)
```

In [3]:

```
# New climatology pre-processed by ESMValTool
dname = '/scratch/hadtq/esmvaltool_output/recipe_autoassess_landsurface_s
fname = 'OBS_ESACCI-SOILMOISTURE_sat_L3S-SSMV-COMBINED-v4.2_Lmon_sm_1999-
import os.path
new = iris.load_cube(os.path.join(dname,fname), iris.Constraint(season_nu
print(new)
print(new.coord('longitude'))
print(new.coord('latitude'))
```

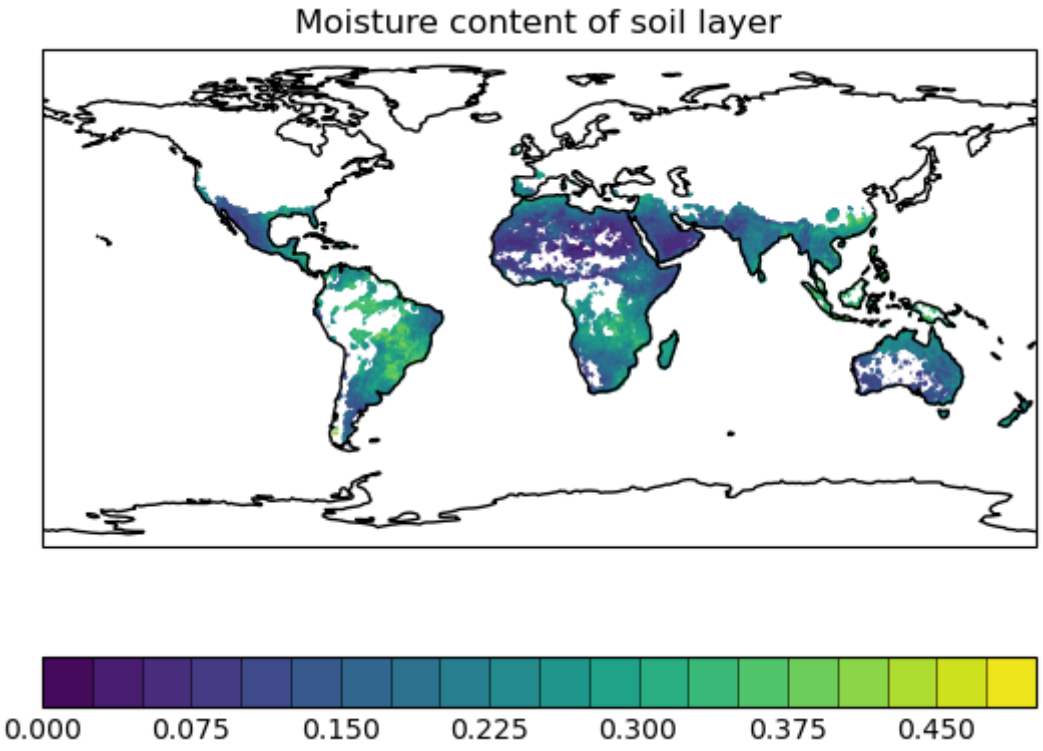
```
Volumetric Moisture in Upper Portion of Soil Column / (m3 m-3) (latitude:
720; longitude: 1440)
    Dimension coordinates:
        latitude                                                      x
-
        longitude                                                     -
x
    Scalar coordinates:
        season_number                                          0
    Cell methods:
        mean                                                   season_num
ber
    Attributes:
        Conventions                                            'CF-1.7'
        host                                                   'mlogin10
3.hpc.dkrz.de'
        reference                                              'Liu et a
l., Hydrol. Earth Syst. Sci., doi:10.5194/hess-15-425-2011, 20 ...'
        software                                               'Created w
ith ESMValTool v2.7.1'
        source                                                 'ftp://ano
n-ftp.ceda.ac.uk/neodc/esacci/soil_moisture/data/'
        source_file                                            '/scratch/
hadtq/esmvaltool_output/recipe_autoassess_landsurface_soilmoi ...'
        tier                                                   2
        title                                                  'ESACCI-SO
ILMOISTURE data reformatted for the ESMValTool v2.0'
        user                                                   'b309057'
DimCoord :  longitude / (degrees)
    points: [1.25000e-01, 3.75000e-01, ..., 3.59625e+02, 3.59875e+02]
    bounds: [
        [0.0000e+00, 2.5000e-01],
        [2.5000e-01, 5.0000e-01],
        ...,
        [3.5950e+02, 3.5975e+02],
        [3.5975e+02, 3.6000e+02]]
    shape: (1440,)  bounds(1440, 2)
    dtype: float64
    standard_name: 'longitude'
    long_name: 'longitude'
    var_name: 'lon'
    circular: True
DimCoord :  latitude / (degrees)
    points: [-89.875, -89.625, ...,  89.625,  89.875]
    bounds: [
        [-90.  , -89.75],
        [-89.75, -89.5 ],
        ...,
        [ 89.5 ,  89.75],
        [ 89.75,  90.  ]]
    shape: (720,)  bounds(720, 2)
    dtype: float64
    standard_name: 'latitude'
    long_name: 'latitude'
    var_name: 'lat'
```

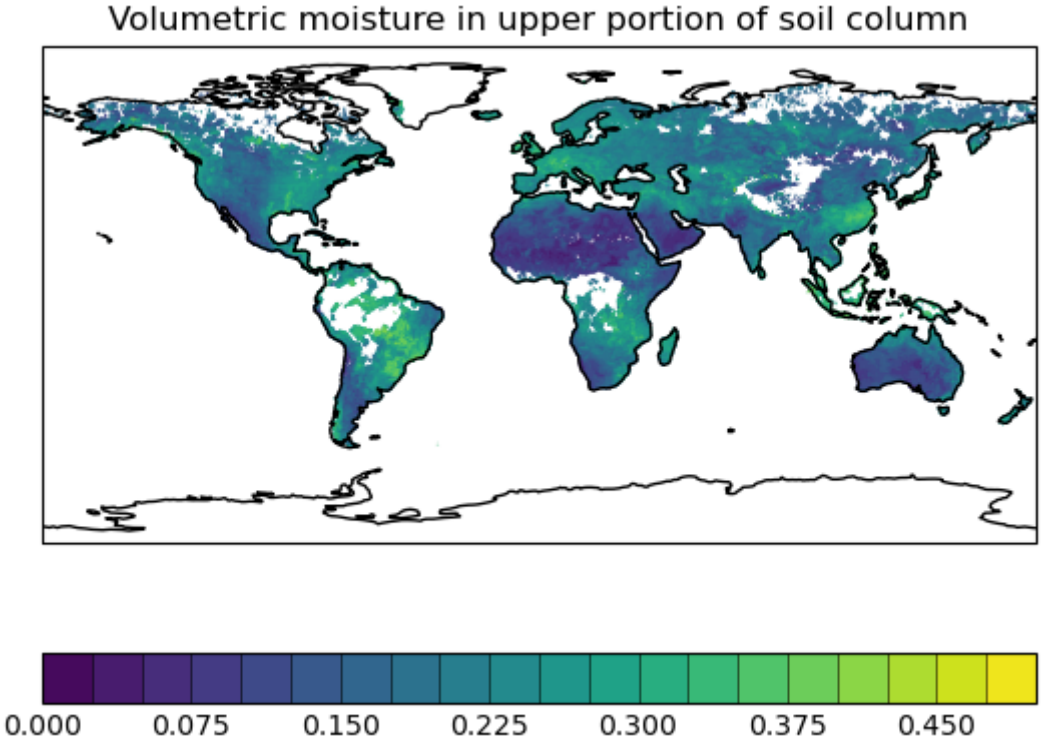
In [4]:
```
import matplotlib.pyplot as plt
%matplotlib inline
import iris.quickplot as qplt
import matplotlib.ticker as mticker

vmin = 0
vmax = 0.5
levels = mticker.MaxNLocator(nbins=21).tick_values(vmin, vmax)

# orig
qplt.contourf(orig, levels=levels)
plt.gca().coastlines()
plt.show()

# new
qplt.contourf(new, levels=levels)
plt.gca().coastlines()
plt.show()
```





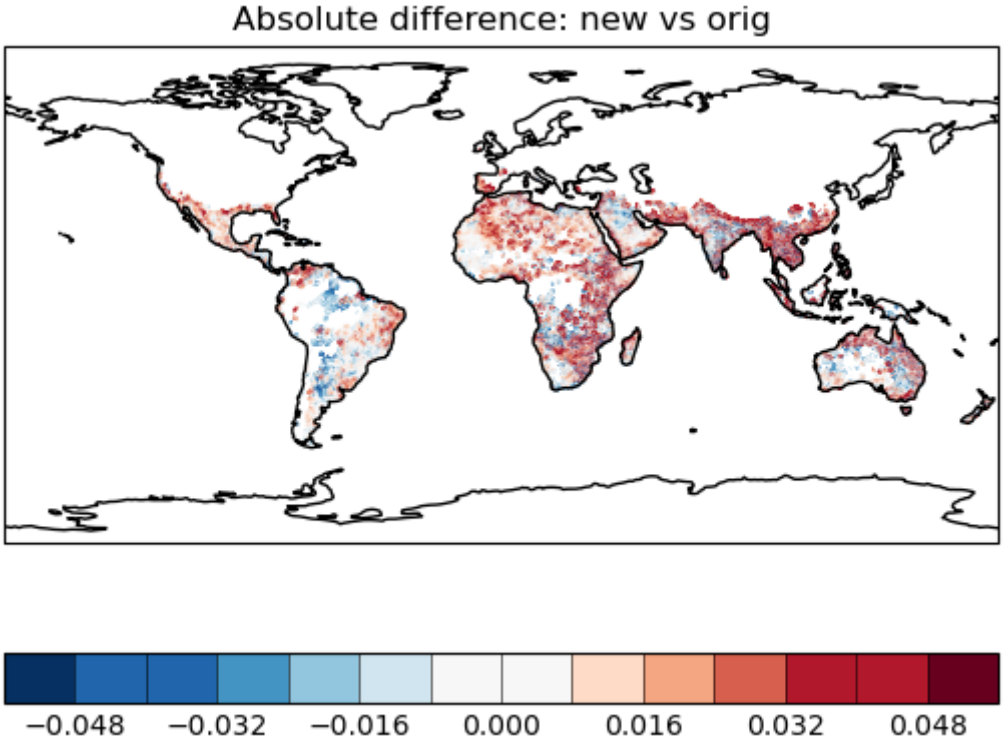
In [5]:
```
# Absolute difference
diff = new.copy()
diff.rename('Absolute difference: new vs orig')
diff.data = new.data - orig.data

import iris.analysis.cartography
grid_areas = iris.analysis.cartography.area_weights(diff)
print('Mean diff:', diff.collapsed(['longitude', 'latitude'], iris.analys
print('Median absolute diff:', np.ma.median(np.ma.absolute(diff.data)))
print('Min diff:', diff.data.min())
print('Max diff:', diff.data.max())


import matplotlib.cm as mpl_cm
cmap = mpl_cm.get_cmap("brewer_RdBu_11")

vmin = -0.05
vmax = 0.05
levels = mticker.MaxNLocator(nbins=14, symmetric=True).tick_values(vmin,
qplt.contourf(diff, levels=levels, cmap=cmap)
plt.gca().coastlines()
plt.show()
```

```
/opt/scitools/conda/deployments/default-2022_11_22/lib/python3.9/site-pac
kages/iris/analysis/cartography.py:394: UserWarning: Using DEFAULT_SPHERI
CAL_EARTH_RADIUS.
  warnings.warn("Using DEFAULT_SPHERICAL_EARTH_RADIUS.")
Mean diff: -0.003729965695949966
Median absolute diff: 0.013476461
Min diff: -0.18191825
Max diff: 0.2688886
```

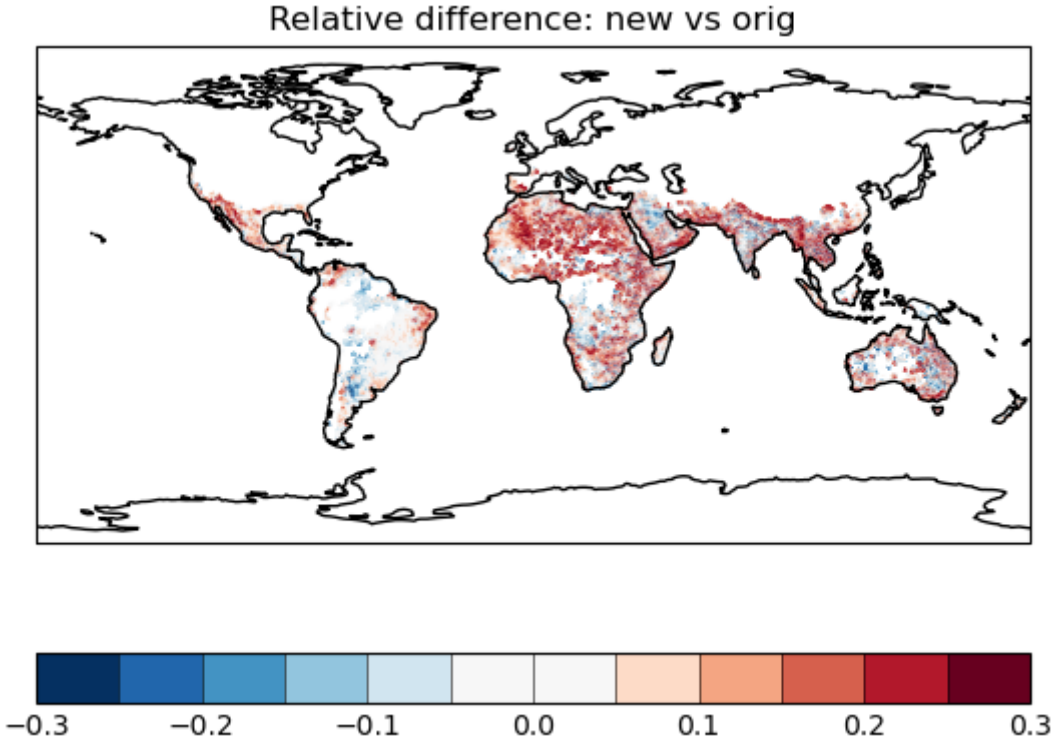


In [6]:
```
# Relative difference
rdiff = new.copy()
rdiff.rename('Relative difference: new vs orig')
rdiff.data = 2 * diff.data / (new.data + orig.data)

print('Median absolute of the relative diffs:', np.ma.median(np.ma.absolu

vmin = -0.3
vmax = 0.3
levels = mticker.MaxNLocator(nbins=14, symmetric=True).tick_values(vmin,
qplt.contourf(rdiff, levels=levels, cmap=cmap)
plt.gca().coastlines()
plt.show()
```

```
Median absolute of the relative diffs: 0.08003883
```



Interpretation

At points where they both have data, typical differences are small: the median absolute difference is more than an order of magnitude smaller than the typical values in the dataset. Also an order of magnitude smaller than typical model-observation differences and therefore will not have a large effect on the metrics produced by this recipe, which are computed as a median-absolute difference between model and observation.

The area-weighted mean difference is an order of magnitude smaller again, indicating no systematic bias between the old and new.

Relative differences (normalised by grid point values of new & old data) are also small, with median absolute value of ~8%. Relative differences of 20-30% are seen in drier regions where the small background values lead to higher relative differences even for very small absolute diffs.