// 1. 定义研究区域：宁夏回族自治区边界

//var ningxiaBounds = ee.Geometry.Rectangle([104.0, 35.0, 107.0, 39.0]);

//Map.centerObject(ningxiaBounds, 7);

//Map.addLayer(ningxiaBounds, {color: 'red'}, '宁夏边界');

//裁剪省界

var ningxiaBounds=ee.FeatureCollection("projects/ace-computer-472400-a2/assets/nningxialine");

Map.centerObject(ningxiaBounds,7);

Map.addLayer(ningxiaBounds,{'color':'yellow'},'研究区');

// 2. 加载MODIS数据

//加载MODIS NDVI数据 (2001-2020)

var modisNDVI = ee.ImageCollection('MODIS/006/MOD13A1')

.filterDate('2001-01-01', '2020-12-31')

.filterBounds(ningxiaBounds)

.select('NDVI'); // NDVI值范围是-2000到10000

//加载EVI数据

var modisEVI = ee.ImageCollection('MODIS/006/MOD13A1')

.filterDate('2001-01-01', '2020-12-31')

.filterBounds(ningxiaBounds)

.select('EVI');

// EVI标准化

var scaleEVI = function(image) {

return image.multiply(0.0001).copyProperties(image, ['system:time\_start']);

};

var modisEVIscaled = modisEVI.map(scaleEVI);

//加载MODIS反射率数据（用于湿度指数计算）

var modisReflectance = ee.ImageCollection('MODIS/006/MOD09A1')

.filterDate('2001-01-01', '2020-12-31')

.filterBounds(ningxiaBounds);

// 3. 数据预处理：将NDVI值转换为标准单位（-1到1）

var scaleNDVI = function(image) {

return image.divide(10000)

.copyProperties(image, ['system:time\_start']);

};

var modisNDVIscaled = modisNDVI.map(scaleNDVI);

// 4. 计算每年的最大NDVI合成（消除云等影响）

var years = ee.List.sequence(2001, 2020);

var annualMaxNDVI = years.map(function(year) {

var startDate = ee.Date.fromYMD(year, 1, 1);

var endDate = ee.Date.fromYMD(year, 12, 31);

return modisNDVIscaled

.filterDate(startDate, endDate)

.max()

.set('year', year)

.set('system:time\_start', startDate.millis()) // 新增时间属性，用于趋势计算

.rename('max\_ndvi');

});

// 转换为ImageCollection

var annualMaxNDVIcol = ee.ImageCollection(annualMaxNDVI);

// 5. 计算20年间NDVI的变化趋势

var addTimeBand = function(image) {

var yearNum = ee.Number(image.get('year')).subtract(2001); // 转换为相对于2001的数值

return image.addBands(ee.Image(yearNum).rename('year').float())

.addBands(ee.Image.constant(1).rename('constant'));

};

var withTimeBands = annualMaxNDVIcol.map(addTimeBand);

// 线性回归计算斜率

var trend = withTimeBands.select(['year', 'constant', 'max\_ndvi'])

.reduce(ee.Reducer.linearRegression(2, 1));

var slope = trend.select('coefficients').arrayGet([0, 0]).rename('slope');

// 6. 计算2001-2020年的平均NDVI和NDVI变化率

var meanNDVI = annualMaxNDVIcol.mean().rename('mean\_ndvi');

var ndvi2001 = ee.Image(annualMaxNDVIcol.filter(ee.Filter.eq('year', 2001)).first());

var ndvi2020 = ee.Image(annualMaxNDVIcol.filter(ee.Filter.eq('year', 2020)).first());

var ndviChange = ndvi2020.subtract(ndvi2001).rename('ndvi\_change');

var ndviChangeRate = ndviChange.divide(20).rename('ndvi\_change\_rate'); // 年变化率

// 7. 可视化参数设置

var ndviPalette = ['red', 'white', 'green'];

var slopePalette = ['blue', 'white','red'];

// 8. 添加图层到地图并裁剪到宁夏边界

Map.addLayer(ndvi2001.clip(ningxiaBounds), {min: 0, max: 0.8, palette: ndviPalette}, '2001年NDVI');

Map.addLayer(ndvi2020.clip(ningxiaBounds), {min: 0, max: 0.8, palette: ndviPalette}, '2020年NDVI');

Map.addLayer(ndviChange.clip(ningxiaBounds), {min: -0.5, max: 0.5, palette: ['brown', 'white', 'green']}, 'NDVI变化(2020-2001)');

Map.addLayer(slope.clip(ningxiaBounds), {min: -0.03, max: 0.03, palette: slopePalette}, 'NDVI变化趋势斜率');

// 9. 创建时间序列图表：宁夏全区平均NDVI年际变化

var yearlyMeanNDVIData = years.map(function(year) {

var img = ee.Image(annualMaxNDVIcol.filter(ee.Filter.eq('year', year)).first());

var mean = img.reduceRegion({

reducer: ee.Reducer.mean(),

geometry: ningxiaBounds,

scale: 500,

maxPixels: 1e9

});

mean = mean ? mean.get('max\_ndvi') : null;

return ee.Feature(null, {

'year': year,

'mean\_ndvi': mean

});

});

var chartData = ee.FeatureCollection(yearlyMeanNDVIData);

var timeSeriesChart = ui.Chart.feature.byFeature(chartData, 'year','mean\_ndvi')

.setChartType('LineChart')

.setOptions({

title: '宁夏2001-2020年平均NDVI时间序列',

vAxis: {title: '平均NDVI'},

hAxis: {title: '年份'},

lineWidth: 2,

pointSize: 4,

series: {0: {color: 'green'}}

});

print('宁夏平均NDVI年际变化', timeSeriesChart);

// 10. 计算不同植被覆盖等级的面积变化

var ndviClasses = function(image) {

var bare = image.lte(0.1).rename('bare');

var low = image.gt(0.1).and(image.lte(0.3)).rename('low');

var medium = image.gt(0.3).and(image.lte(0.5)).rename('medium');

var high = image.gt(0.5).rename('high');

return ee.Image.cat([bare, low, medium, high]);

};

function calculateNDVIClassAreas(year) {

var ndviImage = ee.Image(annualMaxNDVIcol.filter(ee.Filter.eq('year', year)).first()).clip(ningxiaBounds);

var classes = ndviClasses(ndviImage).multiply(ee.Image.pixelArea());

var areas = classes.reduceRegion({

reducer: ee.Reducer.sum(),

geometry: ningxiaBounds,

scale: 500,

maxPixels: 1e9

});

areas = areas ? areas : {};

return {

'bare': ee.Number(areas.get('bare') || 0).divide(10000),

'low': ee.Number(areas.get('low') || 0).divide(10000),

'medium': ee.Number(areas.get('medium') || 0).divide(10000),

'high': ee.Number(areas.get('high') || 0).divide(10000)

};

}

var area2001ha = calculateNDVIClassAreas(2001);

var area2020ha = calculateNDVIClassAreas(2020);

// 11. 创建面积变化图表

var areaChartData = ee.FeatureCollection([

ee.Feature(null, {

'class': '裸地',

'2001': area2001ha.bare,

'2020': area2020ha.bare

}),

ee.Feature(null, {

'class': '低覆盖',

'2001': area2001ha.low,

'2020': area2020ha.low

}),

ee.Feature(null, {

'class': '中覆盖',

'2001': area2001ha.medium,

'2020': area2020ha.medium

}),

ee.Feature(null, {

'class': '高覆盖',

'2001': area2001ha.high,

'2020': area2020ha.high

})

]);

var areaChart = ui.Chart.feature.byFeature(areaChartData, 'class', ['2001', '2020'])

.setChartType('ColumnChart')

.setOptions({

title: '宁夏2001年与2020年各植被覆盖等级面积对比(公顷)',

vAxis: {title: '面积(公顷)'},

hAxis: {title: '植被覆盖等级'},

series: {

0: {color: 'brown', label: '2001年'},

1: {color: 'green', label: '2020年'}

}

});

print(areaChart, '植被覆盖等级面积对比'); // 修正print参数顺序

// 12. 导出结果

Export.image.toDrive({

image: meanNDVI.clip(ningxiaBounds),

description: 'ningxia\_mean\_ndvi\_2001-2020',

folder: 'GEE\_exports',

scale: 500,

region: ningxiaBounds,

maxPixels: 1e13

});

Export.image.toDrive({

image: slope.clip(ningxiaBounds),

description: 'ningxia\_ndvi\_trend\_2001-2020',

folder: 'GEE\_exports',

scale: 500,

region: ningxiaBounds,

maxPixels: 1e13

});

// 13. 计算年度EVI最大值

var years = ee.List.sequence(2001, 2020);

var annualMaxEVI = years.map(function(year) {

var startDate = ee.Date.fromYMD(year, 1, 1);

var endDate = ee.Date.fromYMD(year, 12, 31);

return modisEVIscaled

.filterDate(startDate, endDate)

.max()

.set('year', year)

.rename('max\_evi');

});

var annualMaxEVIcol = ee.ImageCollection(annualMaxEVI);

// 14. 计算每年的EVI最大值的均值，方便生成图表

var yearlyMeanEVI = years.map(function(year) {

var img = ee.Image(annualMaxEVIcol.filter(ee.Filter.eq('year', year)).first());

var mean = img.reduceRegion({

reducer: ee.Reducer.mean(),

geometry: ningxiaBounds,

scale: 500,

maxPixels: 1e9

}).get('max\_evi');

return ee.Feature(null, {

'year': year,

'mean\_evi': mean

});

});

// 将每年EVI的均值转换为FeatureCollection

var chartData = ee.FeatureCollection(yearlyMeanEVI);

// 15. 绘制EVI的时间序列图表（条形图）

var eviChart = ui.Chart.feature.byFeature(chartData, 'year', 'mean\_evi')

.setChartType('ColumnChart')

.setOptions({

title: '宁夏2001-2020年EVI年际变化',

vAxis: {title: 'EVI'},

hAxis: {title: '年份'},

lineWidth: 2,

pointSize: 4,

series: {0: {color: 'green'}}

});

print('宁夏2001-2020年EVI年际变化', eviChart);

// 16. 可视化：展示EVI最大值（2001和2020年）

var eviPalette = ['blue', 'yellow', 'green'];

// 2001年和2020年的EVI最大值

Map.addLayer(ee.Image(annualMaxEVIcol.filter(ee.Filter.eq('year', 2001)).first()).clip(ningxiaBounds),

{min: 0, max: 0.8, palette: eviPalette}, '2001年EVI');

Map.addLayer(ee.Image(annualMaxEVIcol.filter(ee.Filter.eq('year', 2020)).first()).clip(ningxiaBounds),

{min: 0, max: 0.8, palette: eviPalette}, '2020年EVI');

// 17. 导出结果：导出EVI的最大值图像到Google Drive

Export.image.toDrive({

image: annualMaxEVIcol.mean().clip(ningxiaBounds),

description: 'ningxia\_max\_evi\_2001-2020',

folder: 'GEE\_exports',

scale: 500,

region: ningxiaBounds,

maxPixels: 1e13

});

// 18. 计算湿度指数（简化湿度指数模型）

var calculateWetnessIndex = function(image) {

var blue = image.select('sur\_refl\_b03').multiply(0.0001); // 蓝光波段

var green = image.select('sur\_refl\_b04').multiply(0.0001); // 绿光波段

var red = image.select('sur\_refl\_b01').multiply(0.0001); // 红光波段

var nir = image.select('sur\_refl\_b02').multiply(0.0001); // 近红外波段

var swir1 = image.select('sur\_refl\_b05').multiply(0.0001); // 短波红外1波段

var swir2 = image.select('sur\_refl\_b07').multiply(0.0001); // 短波红外2波段

// 简化湿度指数（SWI）的计算公式

var wetness = image.expression(

'((0.1147 \* red) + (0.2489 \* nir) + (0.2408 \* blue) + (0.3132 \* green) - (0.3122 \* swir1) - (0.6416 \* swir2))',

{ red: red, nir: nir, blue: blue, green: green, swir1: swir1, swir2: swir2 }

);

return image.addBands(wetness.rename('wetness'));

};

var modisWetness = modisReflectance.map(calculateWetnessIndex);

// 19. 计算年度湿度指数（湿度指数最大值或均值）

var years = ee.List.sequence(2001, 2020);

var annualMaxWetness = years.map(function(year) {

var startDate = ee.Date.fromYMD(year, 1, 1);

var endDate = ee.Date.fromYMD(year, 12, 31);

var maxWetness = modisWetness

.filterDate(startDate, endDate)

.max()

.set('year', year);

// 选择湿度波段进行重命名

var wetnessBand = maxWetness.select('wetness').rename('max\_wetness');

return wetnessBand.set('year', year);

});

var annualMaxWetnessCol = ee.ImageCollection(annualMaxWetness);

// 20. 创建湿度指数时间序列图表（条形图）

var yearlyMeanWetnessData = years.map(function(year) {

var img = ee.Image(annualMaxWetnessCol.filter(ee.Filter.eq('year', year)).first());

var mean = img.reduceRegion({

reducer: ee.Reducer.mean(),

geometry: ningxiaBounds,

scale: 500,

maxPixels: 1e9

}).get('max\_wetness');

return ee.Feature(null, {

'year': year,

'mean\_wetness': mean

});

});

// 将数据转换为FeatureCollection

var chartData = ee.FeatureCollection(yearlyMeanWetnessData);

// 创建湿度指数时间序列图表（条形图）

var wetnessChart = ui.Chart.feature.byFeature(chartData, 'year', 'mean\_wetness')

.setChartType('ColumnChart')

.setOptions({

title: '宁夏2001-2020年湿度指数年际变化',

vAxis: {title: '湿度指数'},

hAxis: {title: '年份'},

lineWidth: 2,

pointSize: 4,

series: {0: {color: 'blue'}}

});

print('宁夏2001-2020年湿度指数年际变化', wetnessChart);