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Long- term Analysis Data

Landsat 5

Landrat 5 Filename	Date	Cloud Coverage [%]
LT05_L1TP_154011_19850321_20170219_01_T2	21.03.1985	7.0
LT05_L1TP_155011_19850429_20170219_01_T2	29.04.1985	0.0
LT05_L1TP_154011_19850508_20170219_01_T2	08.05.1985	8.0
LT05_L1TP_153011_19850602_20170219_01_T2	02.06.1985	8.0
LT05_L1TP_151011_19860319_20170218_01_T2	19.03.1986	14.0
LT05_L1TP_151012_19860319_20170218_01_T2	19.03.1986	1.0
LT05_L1TP_153011_19860402_20170218_01_T2	02.04.1986	11.0
LT05_L1TP_155011_19860416_20170218_01_T2	16.04.1986	1.0
LT05_L1TP_154011_19860511_20170218_01_T2	11.05.1986	0.0
LT05_L1TP_152011_19870329_20170213_01_T2	29.03.1987	7.0
LT05_L1TP_153011_19870421_20170213_01_T2	21.04.1987	0.0
LT05_L1TP_155011_19870521_20170212_01_T2	21.05.1987	3.0
LT05_L1TP_152011_19880331_20170209_01_T2	31.03.1988	1.0
LT05_L1TP_151011_19880409_20170209_01_T2	09.04.1988	4.0
LT05_L1TP_151012_19880409_20170209_01_T2	09.04.1988	2.0
LT05_L1TP_152011_19880416_20170209_01_T2	16.04.1988	0.0
LT05_L1TP_152012_19880416_20170209_01_T2	16.04.1988	0.0
LT05_L1TP_154011_19880516_20170208_01_T2	16.05.1988	5.0
LT05_L1TP_151012_19880612_20170208_01_T2	12.06.1988	5.0
LT05_L1TP_152012_19890318_20170204_01_T2	18.03.1989	8.0
LT05_L1TP_153011_19890410_20170204_01_T2	10.04.1989	0.0
LT05_L1TP_152011_19890419_20170203_01_T2	19.04.1989	3.0

LT05_L1TP_152012_19890505_20170203_01_T2	05.05.1989	8.0
LT05_L1TP_152011_19900321_20170131_01_T2	21.03.1990	0.0
LT05_L1TP_155011_19900326_20170131_01_T2	26.03.1990	3.0
LT05_L1TP_155011_19900411_20170130_01_T2	11.04.1990	0.0
LT05_L1TP_151012_19910317_20180611_01_T2	17.03.1991	7.0
LT05_L1TP_154011_19910407_20180611_01_T2	07.04.1991	9.0
LT05_L1TP_153011_19920317_20180221_01_T2	17.03.1992	0.0
LT05_L1TP_154011_19920324_20180222_01_T2	24.03.1992	4.0
LT05_L1TP_152011_19920326_20180221_01_T2	26.03.1992	0.0
LT05_L1TP_153011_19920402_20180221_01_T2	02.04.1992	4.0
LT05_L1TP_151011_19920404_20180221_01_T2	04.04.1992	1.0
LT05_L1TP_154011_19920409_20180222_01_T2	09.04.1992	3.0
LT05_L1TP_152012_19920411_20180221_01_T2	11.04.1992	2.0
LT05_L1TP_153011_19920418_20180221_01_T2	18.04.1992	6.0
LT05_L1TP_154011_19920425_20180222_01_T2	25.04.1992	0.0
LT05_L1TP_152011_19920427_20180221_01_T2	27.04.1992	3.0
LT05_L1TP_152012_19920427_20180221_01_T2	27.04.1992	1.0
LT05_L1TP_154011_19920511_20180222_01_T2	11.05.1992	0.0
LT05_L1TP_153011_19920520_20180221_01_T2	20.05.1992	13.0
LT05_L1TP_152011_19930414_20180221_01_T2	14.04.1993	1.0
LT05_L1TP_153011_19930421_20180221_01_T2	21.04.1993	1.0
LT05_L1TP_151011_19930423_20180221_01_T2	23.04.1993	6.0
LT05_L1TP_151011_19930509_20180221_01_T2	09.05.1993	4.0
LT05_L1TP_151012_19930509_20180221_01_T2	09.05.1993	6.0
LT05_L1TP_151011_19930525_20180221_01_T2	25.05.1993	11.0
LT05_L1TP_151011_19930610_20180221_01_T2	10.06.1993	4.0

LT05_L1TP_151012_19930610_20180221_01_T2	10.06.1993	0.0
LT05_L1TP_153011_19950411_20180221_01_T2	11.04.1995	1.0
LT05_L1TP_153011_19950427_20180221_01_T2	27.04.1995	0.0
LT05_L1TP_151011_19950429_20180221_01_T2	29.04.1995	0.0
LT05_L1TP_151012_19950429_20180221_01_T2	29.04.1995	12.0
LT05_L1TP_154011_19950504_20180222_01_T2	04.05.1995	0.0
LT05_L1TP_151011_19950515_20180221_01_T2	15.05.1995	0.0
LT05_L1TP_151012_19950515_20180221_01_T2	15.05.1995	0.0
LT05_L1TP_154011_19950520_20180222_01_T2	20.05.1995	2.0
LT05_L1TP_152012_19950522_20180221_01_T2	22.05.1995	0.0
LT05_L1TP_154011_19960404_20180222_01_T2	04.04.1996	0.0
LT05_L1TP_152011_19960406_20180221_01_T2	06.04.1996	0.0
LT05_L1TP_152012_19960406_20180221_01_T2	06.04.1996	2.0
LT05_L1TP_153011_19960413_20180221_01_T2	13.04.1996	0.0
LT05_L1TP_154011_19960420_20180222_01_T2	20.04.1996	2.0
LT05_L1TP_155011_19960427_20180222_01_T2	27.04.1996	0.0
LT05_L1TP_153011_19960429_20180221_01_T2	29.04.1996	9.0
LT05_L1TP_154011_19960506_20180222_01_T2	06.05.1996	0.0
LT05_L1TP_155011_19960513_20180222_01_T2	13.05.1996	0.0
LT05_L1TP_152011_19960524_20180221_01_T2	24.05.1996	3.0
LT05_L1TP_155011_19960529_20180222_01_T2	29.05.1996	0.0
LT05_L1TP_153011_19980318_20161225_01_T2	18.03.1998	10.0
LT05_L1TP_151011_19980405_20161225_01_T2	05.04.1998	4.0
LT05_L1TP_153011_19980419_20161225_01_T2	19.04.1998	3.0
LT05_L1TP_152011_19980514_20161225_01_T2	14.05.1998	1.0

Landsat 7

Landsat 7 Filename	Date	Cloud Coverage [%]
LE07_L1TP_153011_20000315_20170213_01_T2	15.03.2000	0.0
LE07_L1TP_151012_20000317_20170213_01_T2	17.03.2000	0.0
LE07_L1TP_154011_20000322_20170212_01_T2	22.03.2000	9.0
LE07_L1TP_152011_20000425_20170212_01_T2	25.04.2000	7.0
LE07_L1TP_155011_20000430_20170212_01_T2	30.04.2000	0.0
LE07_L1TP_154011_20000509_20170212_01_T2	09.05.2000	0.0
LE07_L1TP_152011_20010412_20170206_01_T2	12.04.2001	2.0
LE07_L1TP_152012_20010412_20170205_01_T2	12.04.2001	0.0
LE07_L1TP_154011_20030331_20170125_01_T2	31.03.2003	9.0
LE07_L1TP_153011_20000315_20170213_01_T2	15.03.2000	0.0
LE07_L1TP_151012_20000317_20170213_01_T2	17.03.2000	0.0
LE07_L1TP_154011_20000322_20170212_01_T2	22.03.2000	9.0
LE07_L1TP_152012_20030504_20170125_01_T2	04.05.2003	0.0
LE07_L1TP_155011_20050412_20170116_01_T2	12.04.2005	5.0
LE07_L1TP_154011_20050507_20170114_01_T2	07.05.2005	1.0
LE07_L1TP_154011_20080312_20161230_01_T2	12.03.2008	4.0
LE07_L1TP_154011_20090315_20161222_01_T2	15.03.2009	11.0
LE07_L1TP_155011_20090525_20161220_01_T2	25.05.2009	4.0
LE07_L1TP_152012_20100320_20161215_01_T2	20.03.2010	0.0
LE07_L1TP_152012_20100507_20161214_01_T2	07.05.2010	10.0
LE07_L1TP_154011_20110406_20161209_01_T2	06.04.2011	0.0
LE07_L1TP_154011_20120307_20161202_01_T2	07.03.2012	0.0
LE07_L1TP_154011_20120424_20161201_01_T2	24.04.2012	0.0
LE07_L1TP_152012_20120426_20161201_01_T2	26.04.2012	0.0

LE07_L1TP_152012_20130328_20161124_01_T2	28.03.2013	0.0
LE07_L1TP_155011_20130402_20161124_01_T2	02.04.2013	0.0
LE07_L1TP_154011_20130411_20161125_01_T2	11.04.2013	9.0

Landsat 8

Landsat 8 Filename	Date	Cloud Coverage [%]
LC08_L1TP_154011_20140305_20170425_01_T2	05.03.2014	7.25
LC08_L1TP_152011_20140307_20170425_01_T2	07.03.2014	9.98
LC08_L1TP_155011_20140328_20170424_01_T2	28.03.2014	2.78
LC08_L1TP_151012_20140417_20170423_01_T2	17.04.2014	0.37
LC08_L1TP_153011_20140501_20170423_01_T2	01.05.2014	0.0
LC08_L1TP_151012_20150319_20170412_01_T2	19.03.2015	0.69
LC08_L1TP_155011_20150331_20170411_01_T2	31.03.2015	6.26
LC08_L1TP_151012_20150404_20170411_01_T2	04.04.2015	8.18
LC08_L1TP_153011_20150418_20170409_01_T2	18.04.2015	0.29
LC08_L1TP_151011_20150420_20170409_01_T2	20.04.2015	5.55
LC08_L1TP_153011_20150504_20170409_01_T2	04.05.2015	0.11
LC08_L1TP_151011_20150506_20170409_01_T2	06.05.2015	1.93
LC08_L1TP_154011_20160310_20170328_01_T2	10.03.2016	0.00
LC08_L1TP_154011_20160326_20170327_01_T2	26.03.2016	0.00
LC08_L1TP_155010_20160418_20170326_01_T2	18.04.2016	0.07
LC08_L1TP_155011_20160418_20170326_01_T2	18.04.2016	0.72
LC08_L1TP_151011_20160422_20170326_01_T2	22.04.2016	0.01
LC08_L1TP_151012_20160422_20170326_01_T2	22.04.2016	0.00
LC08_L1TP_152011_20160515_20170324_01_T2	15.05.2016	0.66
LC08_L1TP_152012_20160515_20170324_01_T2	15.05.2016	1.30
LC08_L1TP_152011_20170315_20170328_01_T2	15.03.2017	3.84
LC08_L1TP_151012_20170409_20170414_01_T2	09.04.2017	0.04
LC08_L1TP_154011_20170414_20170501_01_T2	14.04.2017	0.00
LC08_L1TP_152011_20170416_20170501_01_T2	16.04.2017	0.00

LC08_L1TP_152011_20170502_20170515_01_T2	02.05.2017	0.00
LC08_L1TP_155010_20170507_20170515_01_T2	07.05.2017	10.34
LC08_L1TP_154011_20170516_20170525_01_T2	16.05.2017	13.2
LC08_L1TP_151011_20180311_20180320_01_T2	11.03.2018	0.59
LC08_L1TP_151012_20180311_20180320_01_T2	11.03.2018	0.06
LC08_L1TP_154011_20180316_20180321_01_T2	16.03.2018	0.04
LC08_L1TP_155011_20180323_20180403_01_T2	23.03.2018	0.00
LC08_L1TP_153011_20180325_20180404_01_T2	25.03.2018	0.09
LC08_L1TP_154011_20180417_20180501_01_T2	17.04.2018	3.96
LC08_L1TP_154011_20180503_20180516_01_T2	03.05.2018	6.41
LC08_L1TP_153011_20180512_20180517_01_T2	12.05.2018	0.22
LC08_L1TP_151012_20180514_20180517_01_T2	14.05.2018	10.45
LC08_L1TP_153011_20190312_20190325_01_T2	12.03.2019	13.95
LC08_L1TP_151011_20190517_20190521_01_T2	17.03.2019	0.00
LC08_L1TP_155010_20190411_20190422_01_T2	11.04.2019	12.99
LC08_L1TP_151012_20190415_20190423_01_T2	15.04.2019	5.45
LC08_L1TP_154011_20190420_20190507_01_T2	20.04.2019	0.06
LC08_L1TP_151012_20190501_20190508_01_T2	01.05.2019	0.00
LC08_L1TP_152011_20190508_20190521_01_T2	08.05.2019	11.33
LC08_L1TP_155011_20190513_20190521_01_T2	13.05.2019	12.09
LC08_L1TP_153011_20190515_20190521_01_T2	15.05.2019	1.68
LC08_L1TP_151012_20190517_20190521_01_T2	17.05.2019	0.01
LC08_L1TP_154011_20200305_20200314_01_T2	05.03.2020	4.28
LC08_L1TP_155011_20200312_20200325_01_T2	12.03.2020	0.05
LC08_L1TP_151012_20200316_20200326_01_T2	16.03.2020	0.06
LC08_L1TP_153011_20200415_20200423_01_T2	15.04.2020	0.00

NDVI Calculation

Performed in Google Earth Engine

```
var region1 =  
  /* color: #d63000 */  
  /* displayProperties: [  
    {  
      "type": "rectangle"  
    }  
  ] */  
  ee.Geometry.Polygon(  
    [[[87.21161214467666, 69.69082656910355],  
      [87.21161214467666, 69.21755752915074],  
      [88.31848470327041, 69.21755752915074],  
      [88.31848470327041, 69.69082656910355]]], null, false);  
  
var region1: Polygon, 4 vertices  
type: Polygon  
coordinates: List (1 element)  
geodesic: false  
  
var regions = ee.FeatureCollection([region1])  
  
Map.addLayer(regions, {}, 'Study Area')  
  
//LANDSAT 5 1985-1998  
  
var L5 = ee.ImageCollection("LANDSAT/LT05/C01/T2_SR")  
  .filterDate('1985-01-01','1998-12-31')  
  .filterBounds(regions)  
  .filter(ee.Filter.lt('CLOUD_COVER', 15))
```

```
//LANDSAT 7 1999-2013
```

```
var L7 = ee.ImageCollection("LANDSAT/LE07/C01/T2_SR")  
    .filterDate('1999-01-01','2013-12-31')  
    .filterBounds(regions)  
    .filter(ee.Filter.lt('CLOUD_COVER', 15))
```

```
//LANDSAT 8
```

```
var L8 = ee.ImageCollection("LANDSAT/LC08/C01/T2_SR")  
    .filterDate('2014-01-01','2020-12-31')  
    .filterBounds(regions)  
    .filter(ee.Filter.lt('CLOUD_COVER', 15))
```

```
//NDVI
```

```
var L5_ndvi = L5.map(function(image){  
    var ndvi = image.expression('(nir-red)/(nir+red)',{  
        red:image.select('B3').multiply(0.0001),  
        nir:image.select('B4').multiply(0.0001)  
    })  
  
    return ndvi.select([0],['ndvi']).set('system:time_start',  
    image.get('system:time_start'))  
})
```

```
var L7_ndvi = L7.map(function(image){  
    var ndvi = image.expression('(nir-red)/(nir+red)',{  
        red:image.select('B3').multiply(0.0001),  
        nir:image.select('B4').multiply(0.0001)  
    })
```

```
    return ndvi.select([0],['ndvi']).set('system:time_start',
    image.get('system:time_start'))
  })
```

```
var L8_ndvi = L8.map(function(image){
  var ndvi = image.expression('(nir-red)/(nir+red)',{
    red:image.select('B4').multiply(0.0001),
    nir:image.select('B5').multiply(0.0001)
  })
```

```
    return ndvi.select([0],['ndvi']).set('system:time_start',
    image.get('system:time_start'))
  })
```

```
//COLLECTION
```

```
var collection = ee.ImageCollection(L5_ndvi.merge(L7_ndvi)).merge(L8_ndvi)
```

```
print(collection.size())
```

```
//TIME SERIES
```

```
var Timeseries = ui.Chart.image.seriesByRegion({
  imageCollection: collection,
  regions: regions,
  reducer: ee.Reducer.mean(),
  band: 'ndvi',
  xProperty: 'system:time_start',
  seriesProperty: 'label'})
```

```
print(Timeseries)
```

```
//CHART STYLE
```

```

var chartStyle = {
  title: 'NDVI values from 1985 to 2021',
  hAxis: {
    title: 'Year',
    titleTextStyle: {italic: false, bold: true},
    gridlines: {color: 'FFFFFF'}
  },
  vAxis: {
    title: 'NDVI',
    titleTextStyle: {italic: false, bold: true},
    gridlines: {color: 'FFFFFF'},
    format: 'short',
    baselineColor: 'FFFFFF'
  },
  series: {
    0: {lineWidth: 3, color: 'E37D05', pointSize: 7}
  },
  chartArea: {backgroundColor: 'EBEBEB'}
};

//TIME SERIES
var Timeseries = ui.Chart.image.seriesByRegion({
  imageCollection: collection,
  regions: regions,
  reducer: ee.Reducer.mean(),
  band: 'ndwi',
  xProperty: 'system:time_start',
  seriesProperty: 'label'})
// Apply custom style properties to the chart.
Timeseries.setOptions(chartStyle);
print(Timeseries)

```

```
print(L5)
```

Sentinel 2 Visual Assessment

Google Earth Engine performance:

NDVI

Imports (3 entries)

```
var ROI = /* color: #d63000 */ee.Geometry.Point([87.91574367179895, 69.44866093989289]),

  S2 = ee.ImageCollection("COPERNICUS/S2"),

  geometry = /* color: #1bd60a */ee.Geometry.Point([88.18882182947851, 69.3546897008338]);

var S2: ImageCollection "Sentinel-2 MSI: MultiSpectral Instrument, Level-1C"

var ROI: Point (87.92, 69.45)

type: Point

coordinates: [87.91574367179895,69.44866093989289]

0: 87.91574367179895

1: 69.44866093989289

var geometry: Point (88.19, 69.35)

type: Point

coordinates: [88.19232136249256,69.35270358972453]

0: 88.19232136249256

1: 69.35270358972453

var selection = S2.filterBounds(ROI)

  .filterDate('2020-05-25', '2020-07-10')

  .sort('CLOUD_COVERAGE_ASSESSMENT')

  .first()

//TRUE

var trueColor = {

  bands:['B4', 'B3', 'B2'],

  min:0,

  max:3000
```

```
}
```

```
Map.addLayer(selection, trueColor, 'True Color')
```

```
//FALSE
```

```
var falseColor = {  
  bands:['B8', 'B4', 'B3'],  
  min:0,  
  max:3000  
}
```

```
Map.addLayer(selection, falseColor, 'False Color')
```

```
//NDVI
```

```
var NDVI = selection.expression(  
  '(NIR-RED)/(NIR+RED)', {  
    NIR: selection.select('B8'),  
    RED: selection.select('B4')  
  }  
)  
Map.addLayer(NDVI, {min:0, max:1}, 'NDVI')
```

```
//NDWI
```

```
var NDWI = selection.expression(  
  '(G-NIR)/(G+NIR)', {  
    G: selection.select('B3'),  
    NIR: selection.select('B8')  
  }  
)
```

```
Map.addLayer(NDWI, {min:0.5, max:1, palette: ['44c9f1', '1637f1']}, 'NDWI')
```

```
//Map.addLayer(NDWI, {min:0.5, max:1}, 'NDWI')
```

```
var selection1 = S2.filterBounds(ROI)
```

```
    .filterDate('2016-05-25', '2016-07-10')
```

```
    .sort('CLOUD_COVERAGE_ASSESSMENT')
```

```
    .first()
```

```
//TRUE
```

```
var trueColor = {
```

```
  bands:['B4', 'B3', 'B2'],
```

```
  min:0,
```

```
  max:3000
```

```
}
```

```
Map.addLayer(selection1, trueColor, 'True Color 2016')
```

```
//FALSE
```

```
var falseColor = {
```

```
  bands:['B8', 'B4', 'B3'],
```

```
  min:0,
```

```
  max:3000
```

```
}
```

```
Map.addLayer(selection1, falseColor, 'False Color 2016')
```

```
//NDVI
```

```
var NDVI = selection1.expression(
```

```
  '(NIR-RED)/(NIR+RED)', {
```



```

    NIR: selection1.select('B8'),
    RED: selection1.select('B4')
  }
)
Map.addLayer(NDVI, {min:0, max:1}, 'NDVI 2016')

//NDWI

var NDWI = selection1.expression(
  '(G-NIR)/(G+NIR)', {
    G: selection1.select('B3'),
    NIR: selection1.select('B8')
  }
)
Map.addLayer(NDWI, {min:0.5, max:1, palette: ['44c9f1', '1637f1']}, 'NDWI 2016')

var selection2 = S2.filterBounds(ROI)
  .filterDate('2021-05-25', '2021-07-10')
  .sort('CLOUD_COVERAGE_ASSESSMENT')
  .first()

//TRUE
var trueColor = {
  bands:['B4', 'B3', 'B2'],
  min:0,
  max:3000
}

Map.addLayer(selection2, trueColor, 'True Color 2021')

//FALSE

```

```
var falseColor = {  
  bands:['B8', 'B4', 'B3'],  
  min:0,  
  max:3000  
}
```

```
Map.addLayer(selection2, falseColor, 'False Color 2021')
```

```
//NDVI
```

```
var NDVI = selection2.expression(  
  '(NIR-RED)/(NIR+RED)', {  
    NIR: selection2.select('B8'),  
    RED: selection2.select('B4')  
  }  
)
```

```
Map.addLayer(NDVI, {min:0, max:1}, 'NDVI 2021')
```

```
//NDWI
```

```
var NDWI = selection2.expression(  
  '(G-NIR)/(G+NIR)', {  
    G: selection2.select('B3'),  
    NIR: selection2.select('B8')  
  }  
)
```

```
Map.addLayer(NDWI, {min:0.5, max:1, palette: ['44c9f1', '1637f1']}, 'NDWI 2021')
```

```
print(selection1)
```

```
print(selection2)
```

JRC Yearly Water Classification History, v1.3

(based on https://developers.google.com/earth-engine/datasets/catalog/JRC_GSW1_3_YearlyHistory)

Imports (1 entry)

var geometry =

```
/* color: #d63000 */
```

```
/* displayProperties: [
```

```
{
```

```
  "type": "rectangle"
```

```
}
```

```
] */
```

ee.Geometry.Polygon(

```
[[[82.33528451123347, 70.30972388670126],
```

```
  [82.33528451123347, 68.43782931339514],
```

```
  [90.06965951123347, 68.43782931339514],
```

```
  [90.06965951123347, 70.30972388670126]]], null, false);
```

var geometry: Polygon, 4 vertices

type: Polygon

coordinates: List (1 element)

0: List (5 elements)

geodesic: false

var dataset = ee.ImageCollection("JRC/GSW1_3/YearlyHistory");

var visualization = {

```
  bands: ['waterClass'],
```

```
  min: 0.0,
```

```
  max: 3.0,
```

```
  palette: ['cccccc', 'ff0000', 'ffffff', '0000ff']
```

```
};
```

Map.addLayer(dataset, visualization, 'Water Class');