A 1986-2014 AVHRR NDVI dataset for Svalbard

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AVHRR series of satellites/instruments

Satellite name	Launch date	Service start	Service end
TIROS-N	13 Oct 1978	19 Oct 1978	30 Jan 1980
NOAA-6	27 Jun 1979	27 Jun 1979	16 Nov 1986
NOAA-7	23 Jun 1981	24 Aug 1981	7 Jun 1986
NOAA-8	28 Mar 1983	3 May 1983	31 Oct 1985
NOAA-9	12 Dec 1984	25 Feb 1985	11 May 1994
NOAA-10	17 Sep 1986	17 Nov 1986	17 Sep 1991
NOAA-11	24 Sep 1988	8 Nov 1988	13 Sep 1994
NOAA-12	13 May 1991	14 May 1991	15 Dec 1994
NOAA-14	30 Dec 1994	30 Dec 1994	23 May 2007
NOAA-15	13 May 1998	13 May 1998	Present
NOAA-16	21 Sep 2000	21 Sep 2000	9 Jun 2014
NOAA-17	24 Jun 2002	24 Jun 2002	10 Apr 2013
NOAA-18	20 May 2005	30 Aug 2005	present
NOAA-19	6 Feb 2009	2 Jun 2009	present
MetOp-A	19 Oct 2006	20 Jun 2007	present
MetOp-B	17 Sept 2012	24 April 2013	present

AVHRR sensor characteristics

AVHRR/2 (NOAA-7 through 14)

Band	Wavelength Region (μm)	Resolution (km)
1	0.58-0.68 (red)	1.1
2	0.725-1.10 (near-IR)	1.1
3	3.55-3.93 (high-temp TIR)	1.1
4	10.3-11.3 (TIR)	1.1
5	11.5-12.5 (TIR)	1.1

AVHRR/3 (NOAA-15 through 19)

Band	Wavelength Region (μm)	Resolution (km)
1	0.58-0.68 (red)	1.1
2	0.73-0.98 (near-IR)	1.1
3a	1.58-1.63 (mid-IR)	1.1
3b	3.54-3.87 (high-temp TIR)	1.1
4	10.3-11.3 (TIR)	1.1
5	11.5-12.4 (TIR)	1.1

Data types

- High Resolution Picture Transmission **(HRPT)**
  - Full resolution image data transmitted to a ground station as they are collected. The average instantaneous field-of-view of 1.4 milliradians yields a HRPT ground resolution of approximately 1.1 km at the satellite nadir from the nominal orbit altitude of 833 km.
- Local Area Coverage **(LAC)**
  - Full resolution data that are recorded on an onboard tape for subsequent transmission during a station overpass. The average instantaneous field-of-view of 1.4 milliradians yields a LAC ground resolution of approximately 1.1 km at the satellite nadir from the nominal orbit altitude of 833 km.
- Global Area Coverage **(GAC)**
  - Data are derived from a sample averaging of the full resolution AVHRR data. Four out of every five samples along the scan line are used to compute one average value and the data from only every third scan line are processed, yielding 1.1 km by 4 km resolution at the subpoint

Data processing

- AVHRR local area coverage (LAC) scenes was downloaded from archive to cover the summer season (i.e. June through September) for the period 1986-2014 (see table 1). To cover the whole 29 year period, data from nine satellites were used (NOAA-9, 11, 12, 15, 17, 18, 19, MetOP-A, MetOP-B).
- The individual channel digital counts were transformed to calibrated reflectances using the models found in (Rao & Chen, 1995), for NOAA-9 and NOAA-11, (Heidinger et al., 2003) for NOAA-12 and (Thank & Coakley, 2002) for NOAA-15.
- These models provide time-varying calibration coefficients, compensated for sensor degradation.
- For satellites from NOAA-17 and later, the updated calibration coefficients available in the header of the data files, were utilized.
- The channels on the various AVHRR sensors cover slightly different spectral ranges. Hence, the NDVI values calculated from different sensors will vary slightly. Therefore, the NDVI values from the various AVHRR sensors were cross-calibrated to NOAA-9 utilizing the models from (Trishchenko et al., 2002; Trishchenko 2009).

Geocoding

- Data products are first geo-rectified onto a map projection using the coordinate grid accompanying data sets, using the method described in (NOAA KLM User's Guide) and (NOAA Polar Orbiter Data (POD) User's Guide).
  - However, for the earliest satellites (prior to ca. year 2000), the included coordinate grid is very imprecise, and deviations of more than 20 km are not uncommon. Although precise orbital parameters are available for all NOAA satellites, the AVHRR data set does not contain information on satellite's attitude. Hence, we cannot utilize the precise orbital information to post process the AVHRR data to get more precise geo-location. Instead we had to do a manually coregistration of every scene used in the NDVI time series. Prior to this work, a subset of the best scenes (i.e. minimum clouds and free of visual artifacts and scan line errors) was selected to span the whole 23 year time period reducing the dataset to 2590 scenes (until 2009). Later scenes are unproblematic.
- Spatial resolution of the final product was set to 1km
- Finally, two composite NDVI images were generated for each month, taking the maximum pixel-wise NDVI value in the period from day 1 to day 15 and from day 16 to the end of the month, respectively.
  - This minimizes atmospheric effects, without an explicit atmospheric correction being required. In addition scan-angle effects, cloud contamination, and shadow effects due to varying solar-zenith-angles and solar azimuth-angles are minimized (Holben 1986).

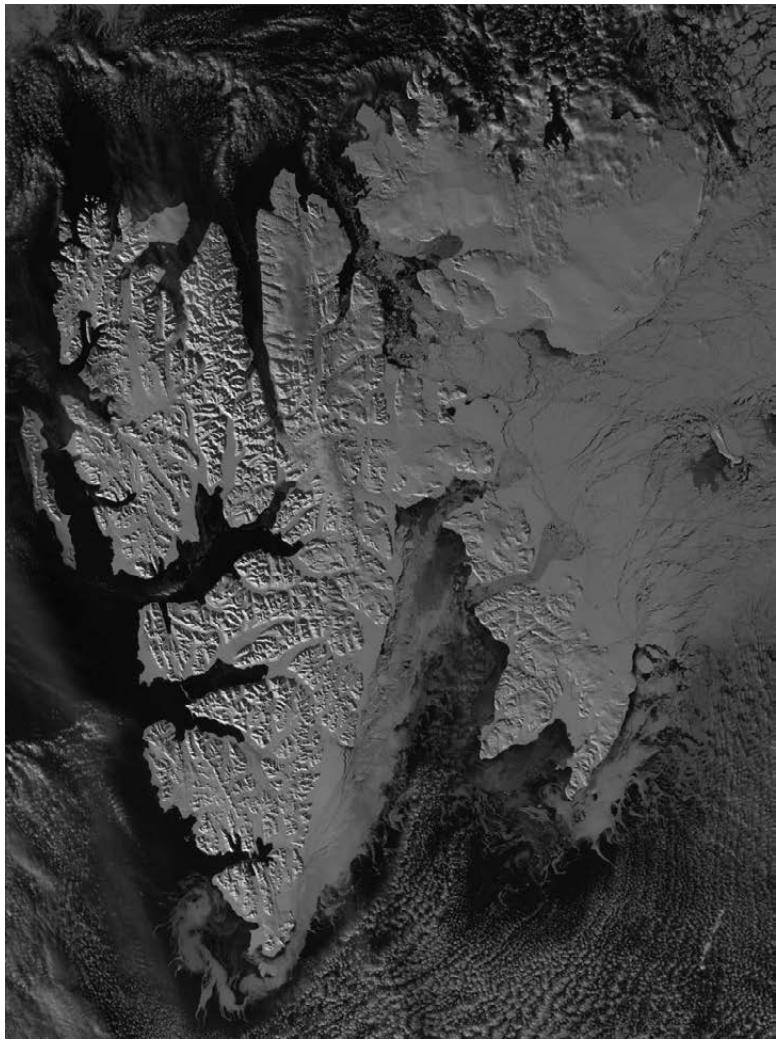
Available data over Svalbard

- Aproximately 12 000 scenes 1986-2014
- Will also process 2015

Year	Jun 1-15	Jun 16-30	July 1-15	July 16-31	Aug 1-16	Aug16-31	Sum (processed, warped scener)	Sum (rawdata)
1986	6 (22)	8 (31)	4 (21)	3 (29)	4 (26)	3 (28)	28	157
1987	1 (8)	2 (14)	2 (14)	2 (15)	1 (15)	3 (14)	11	80
1988	3 (16)	3 (19)	3 (18)	4 (16)	3 (19)	3 (14)	19	102
1989	3 (19)	4 (32)	3 (27)	3 (31)	4 (22)	4 (27)	21	158
1990	3 (22)	4 (25)	4 (24)	4 (24)	3 (24)	4 (19)	22	138
1991	4 (27)	3 (20)	4 (16)	4 (15)	2 (12)	2 (11)	19	101
1992	3 (64)	5 (58)	5 (54)	3 (48)	3 (51)	3 (52)	22	327
1993	4 (54)	4 (52)	6 (48)	4 (61)	4 (52)	3 (56)	25	323
1994	2 (60)	4 (55)	4 (58)	5 (55)	2 (54)	4 (63)	21	345
1995	4 (43)	4 (47)	2 (47)	3 (43)	3 (42)	3 (50)	19	272
1996	3 (43)	4 (37)	4 (50)	3 (48)	3 (40)	2 (45)	19	263
1997	1 (36)	5 (41)	1 (30)	2 (34)	2 (37)	1 (37)	12	215
1998	4 (37)	1 (39)	1 (37)	0 (48)	1 (35)	2 (40)	9	236
1999	2 (44)	2 (44)	3 (43)	2 (50)	1 (43)	0 (50)	10	274
2000	4 (32)	6 (33)	5 (33)	3 (26)	1 (43)	2 (58)	21	225
2001	4 (46)	8 (43)	10 (45)	9 (51)	6 (40)	3 (52)	40	277
2002	7 (27)	10 (28)	5 (24)	7 (33)	6 (9)	6 (12)	41	133
2003	7 (41)	13 (46)	17 (46)	15 (39)	15 (46)	15 (46)	82	264
2004	0 (43)	1 (56)	1 (71)	3 (55)	2 (32)	0 (39)	7	296
2005	12 (29)	11 (23)	14 (30)	18 (44)	11 (37)	8 (26)	74	189
2006	1 (33)	2 (29)	1 (29)	3 (29)	5 (31)	2 (33)	14	184
2007	2 (141)	4 (55)	5 (32)	3 (31)	0 (30)	2 (29)	16	318
2008	3 (135)	1 (136)	4 (134)	3 (158)	3 (142)	3 (145)	17	850
2009	4 (121)	3 (123)	3 (104)	2 (47)	2 (116)	1 (128)	15	639
2010	0 (52)	3 (131)	0 (127)	2 (142)	2(128)	1 (139)	8	719
2011	5 (29)	6 (27)	4 (33)	6 (22)	1 (15)	3 (9)	25	135
2012	7 (129)	6 (117)	5 (115)	7 (121)	8 (116)	5 (121)	38	719
2013	2 (313)	0 (312)	0 (318)	6 (341)	0 (318)	1 (340)	9	1942
2014	5 (178)	6 (185)	7 (188)	8 (184)	7 (183)	6 (201)	39	1119

However, it does not look like this!

- Cloud cover is a major problem!
- 700 Scenes of good quality!!!



Svalbard vegetation map

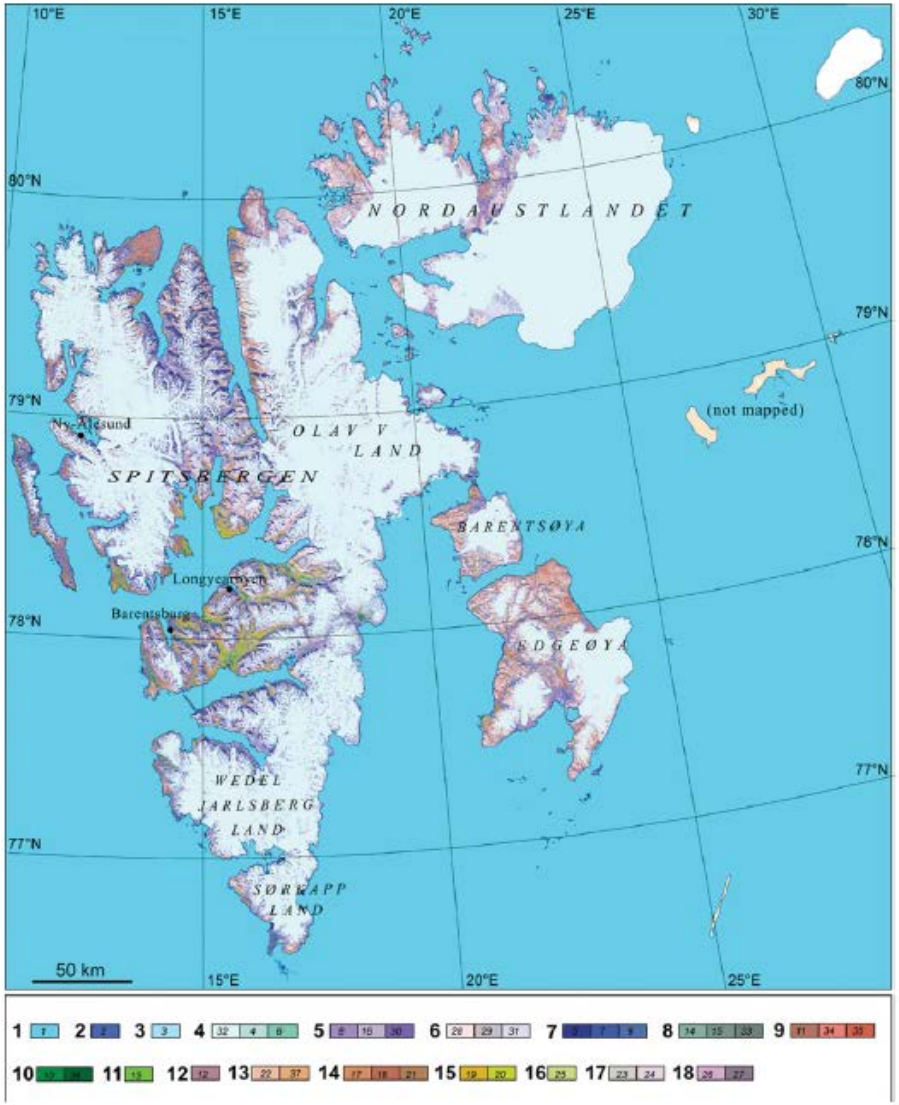
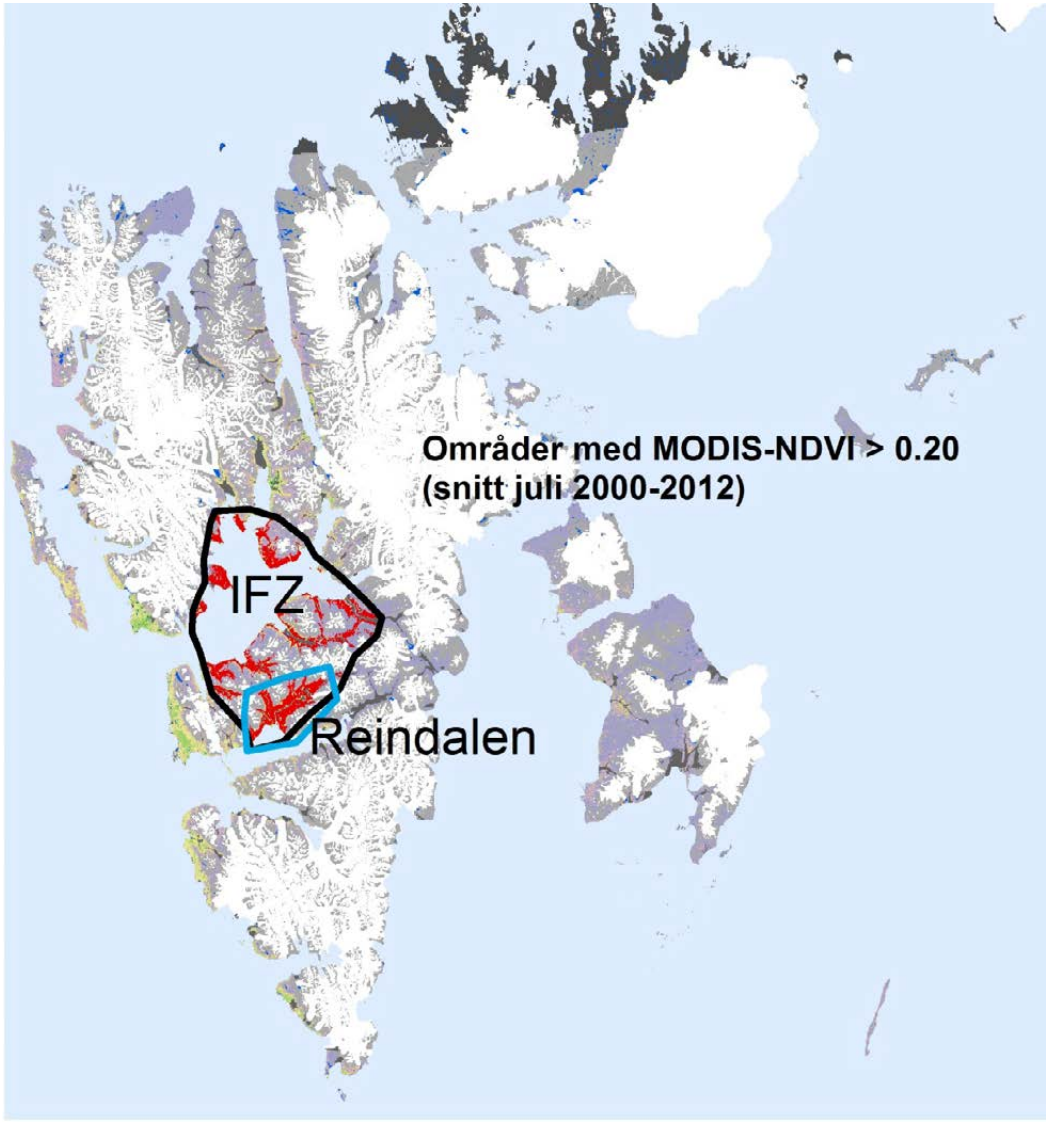
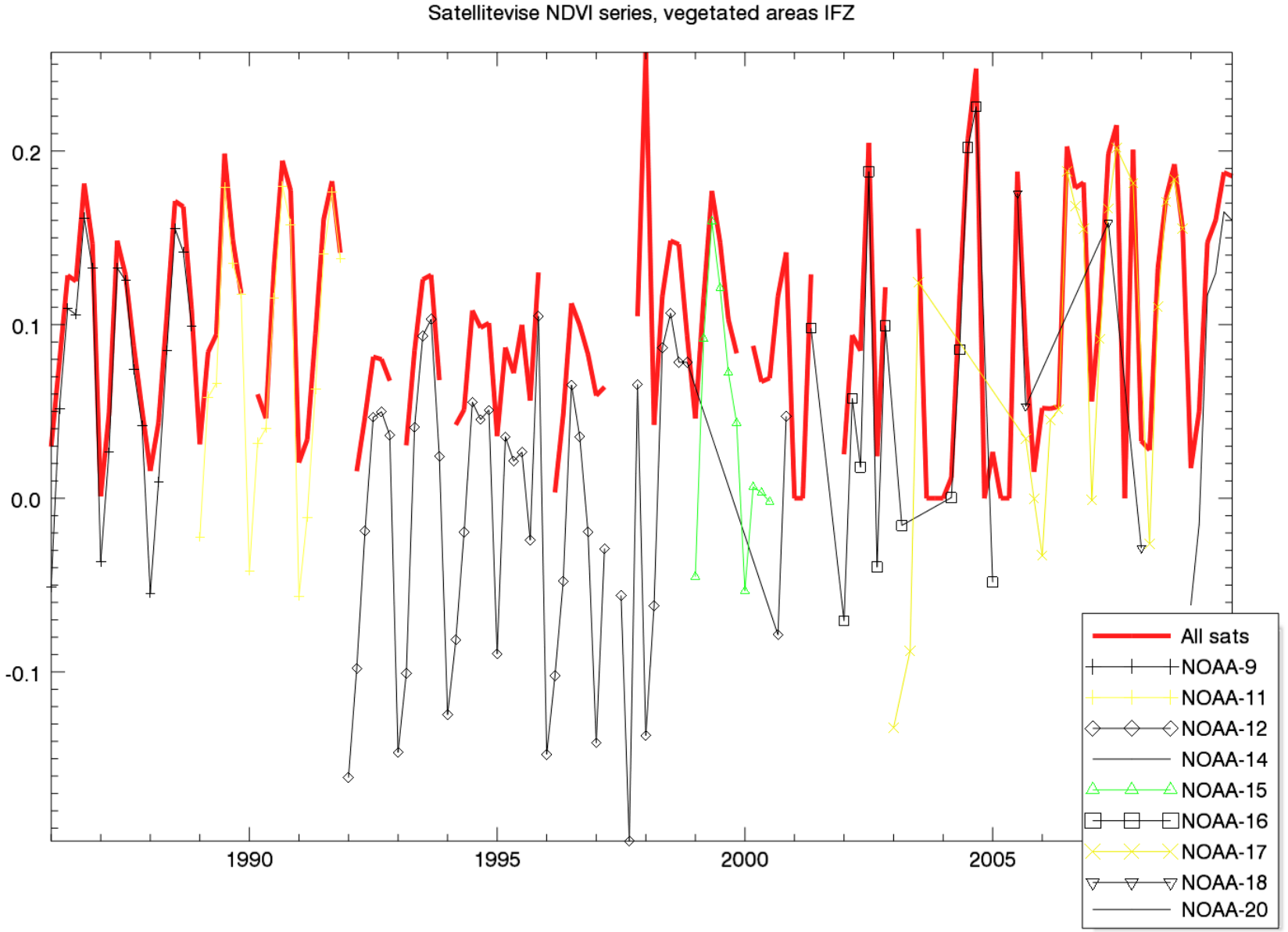


Fig. 3. Vegetation map of Svalbard, originally at scale 1:500 000. The map is differentiated into 37 spectral classes and further aggregated into 18 map units. The descriptions of the map units are given in section 3.2.

Study area

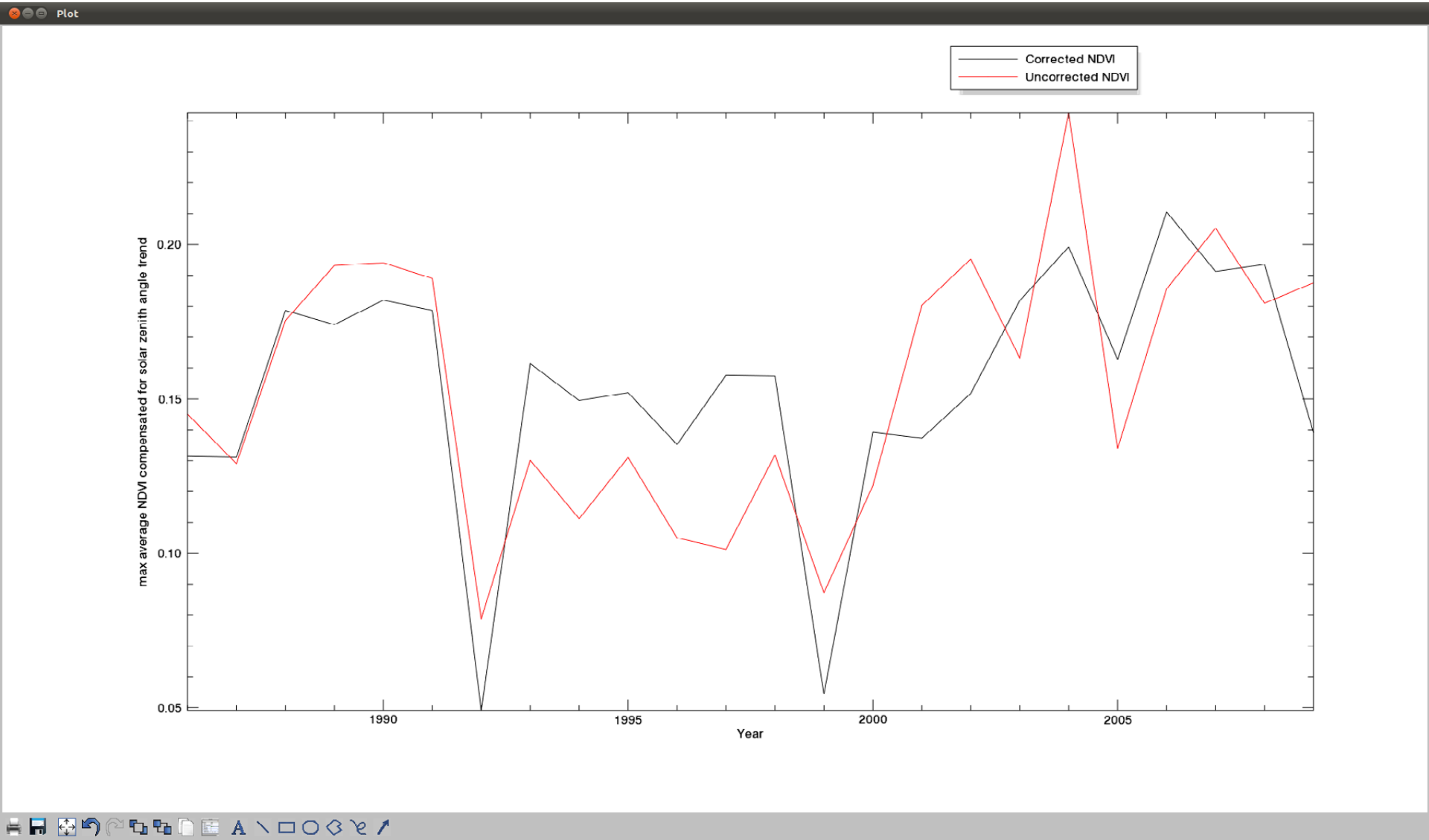

Områder med MODIS-NDVI > 0.20
(snitt juli 2000-2012)
IFZ
Reindalen

Plot

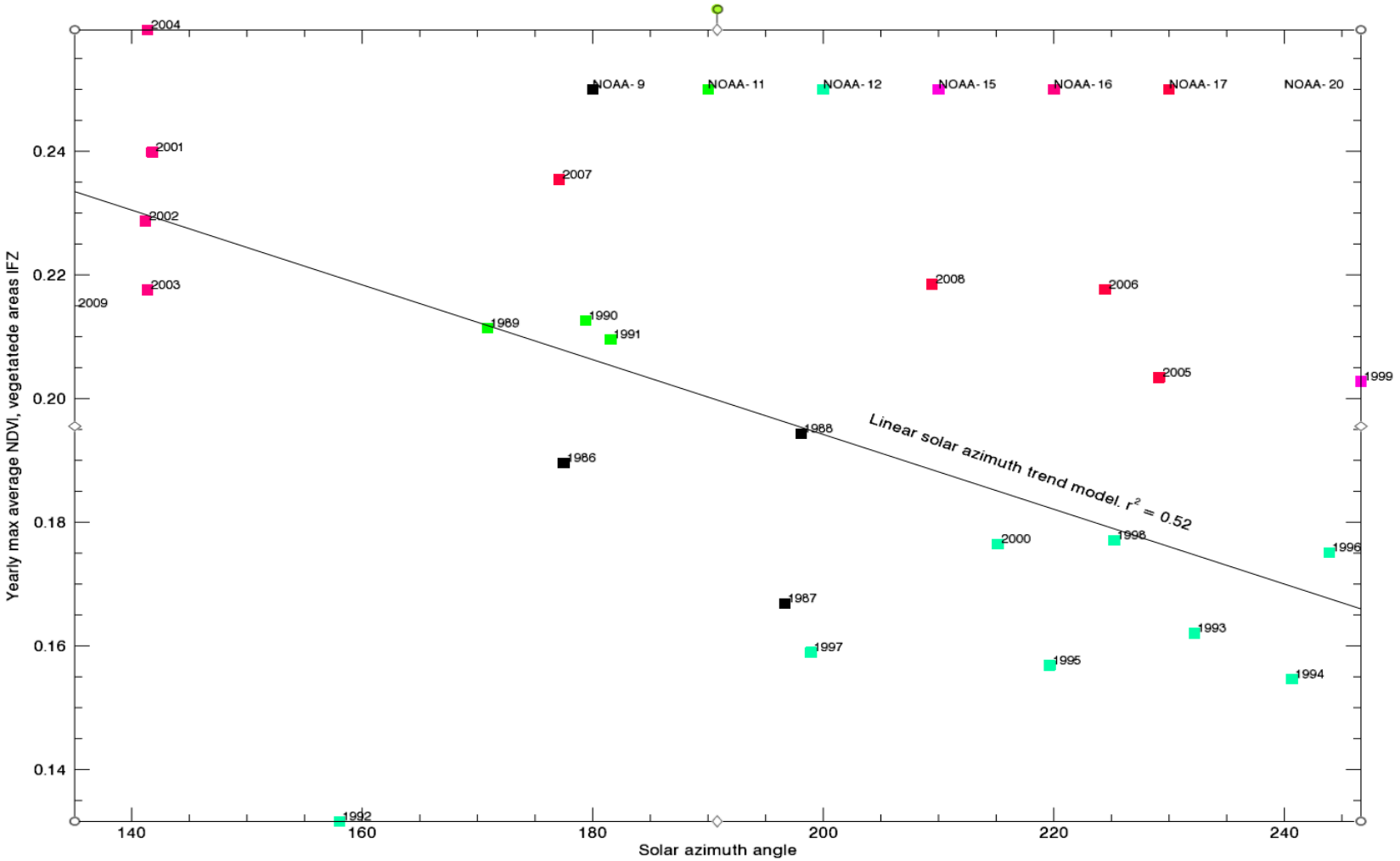


[1416,1101]

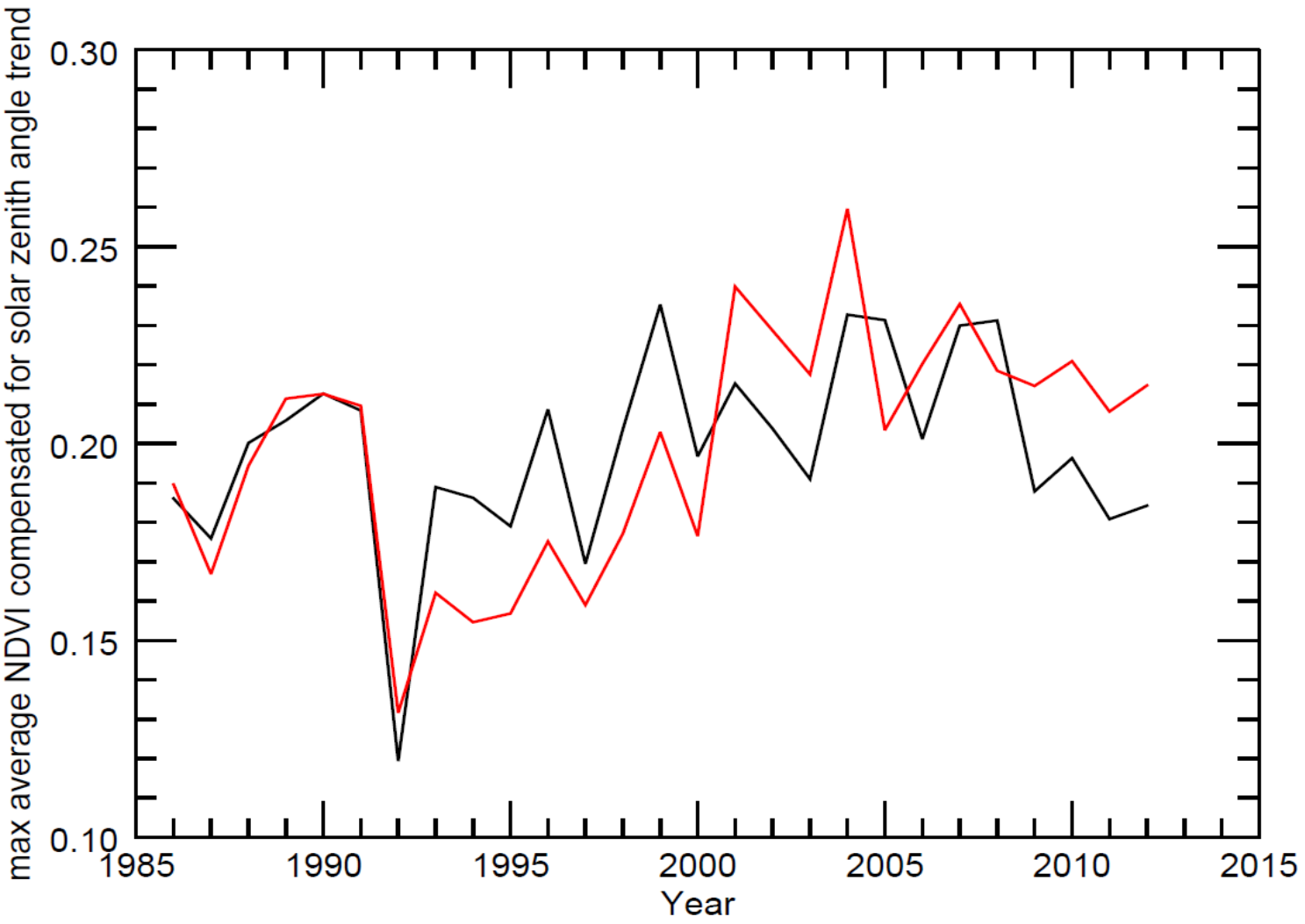
EMD (Empirical Mode Decomposition) corrected for sun zenith angle

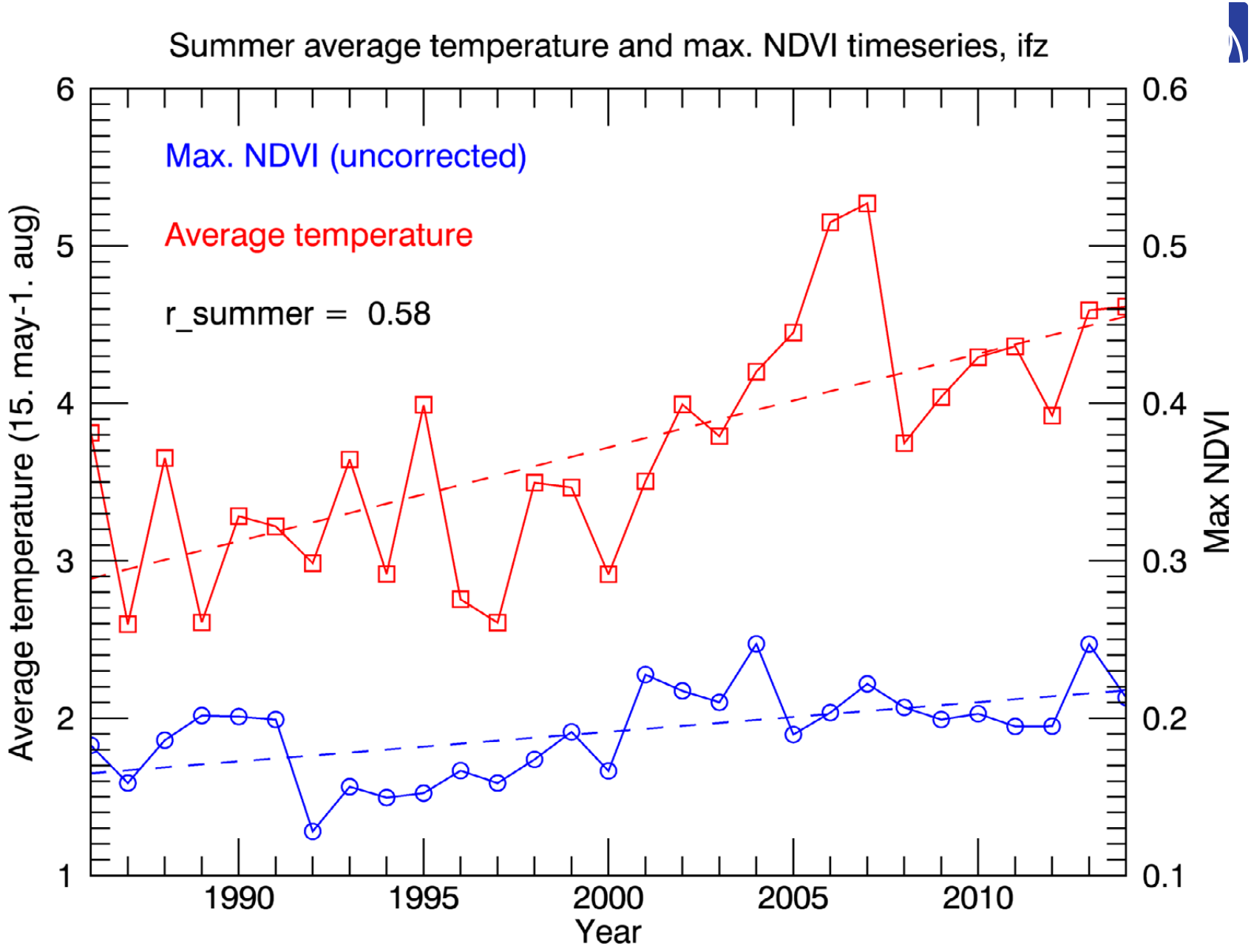


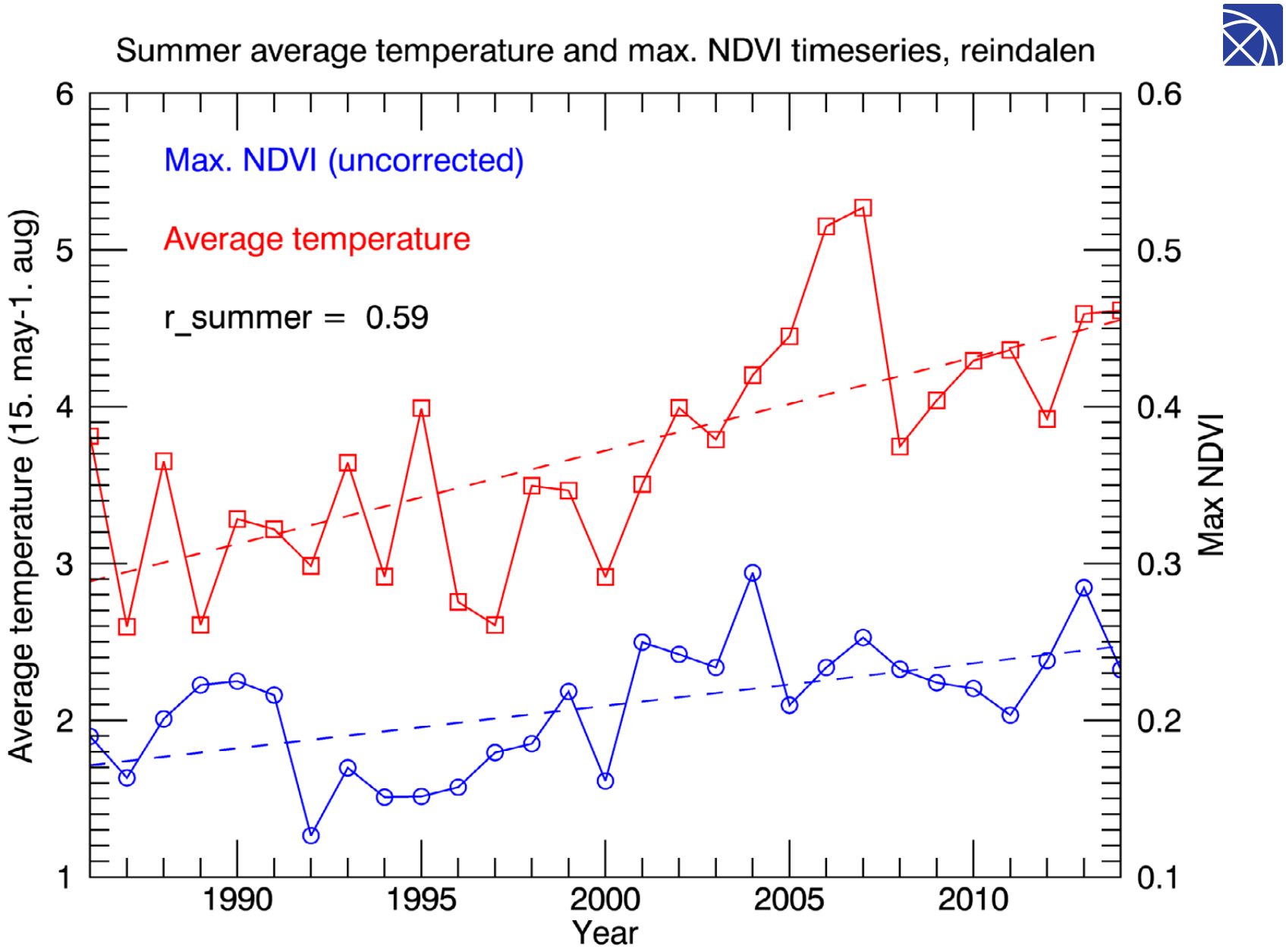
Sun azimuth angle dependency

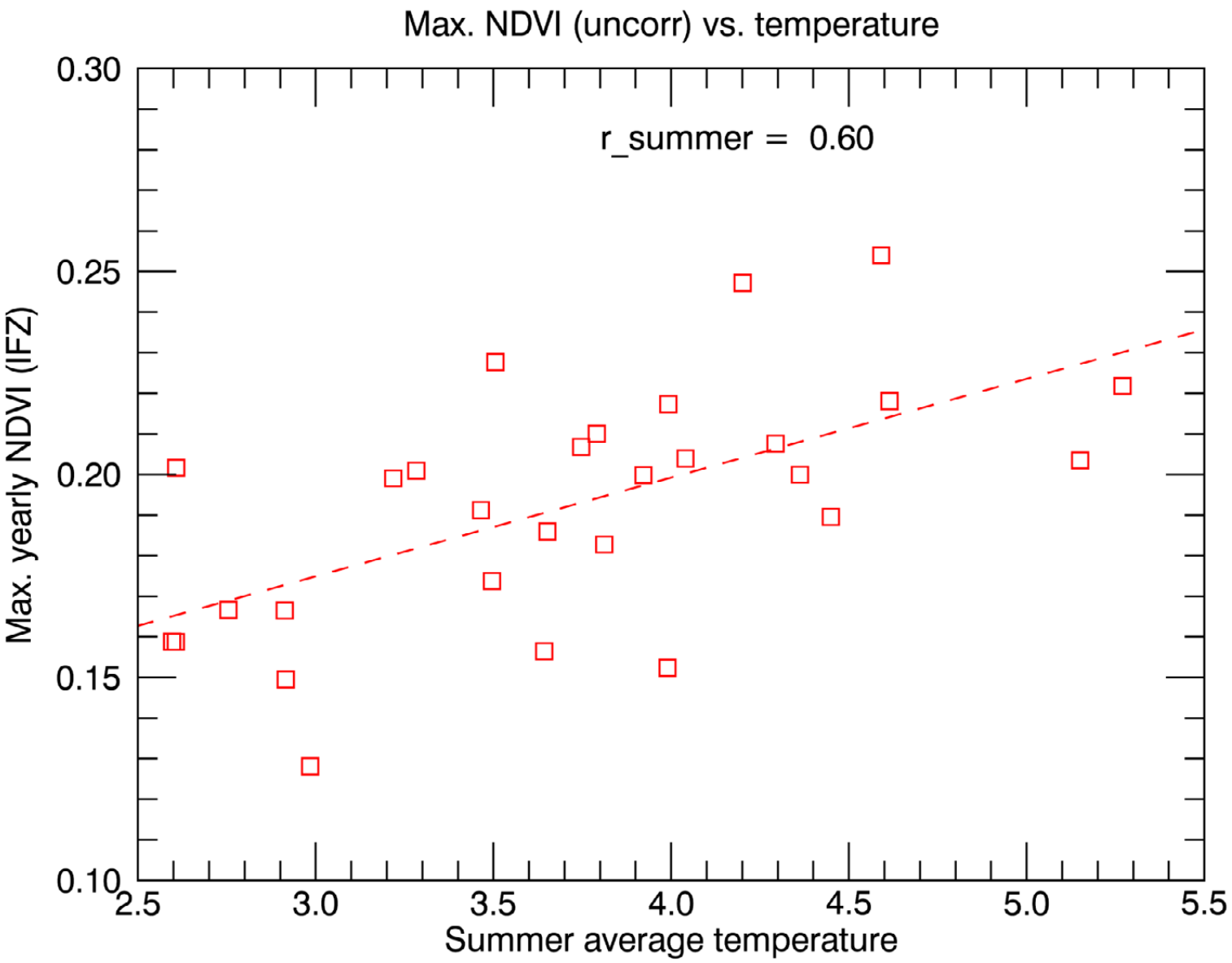


Calibrated against NOAA 9-(red) and azimuth angle corrected (black)

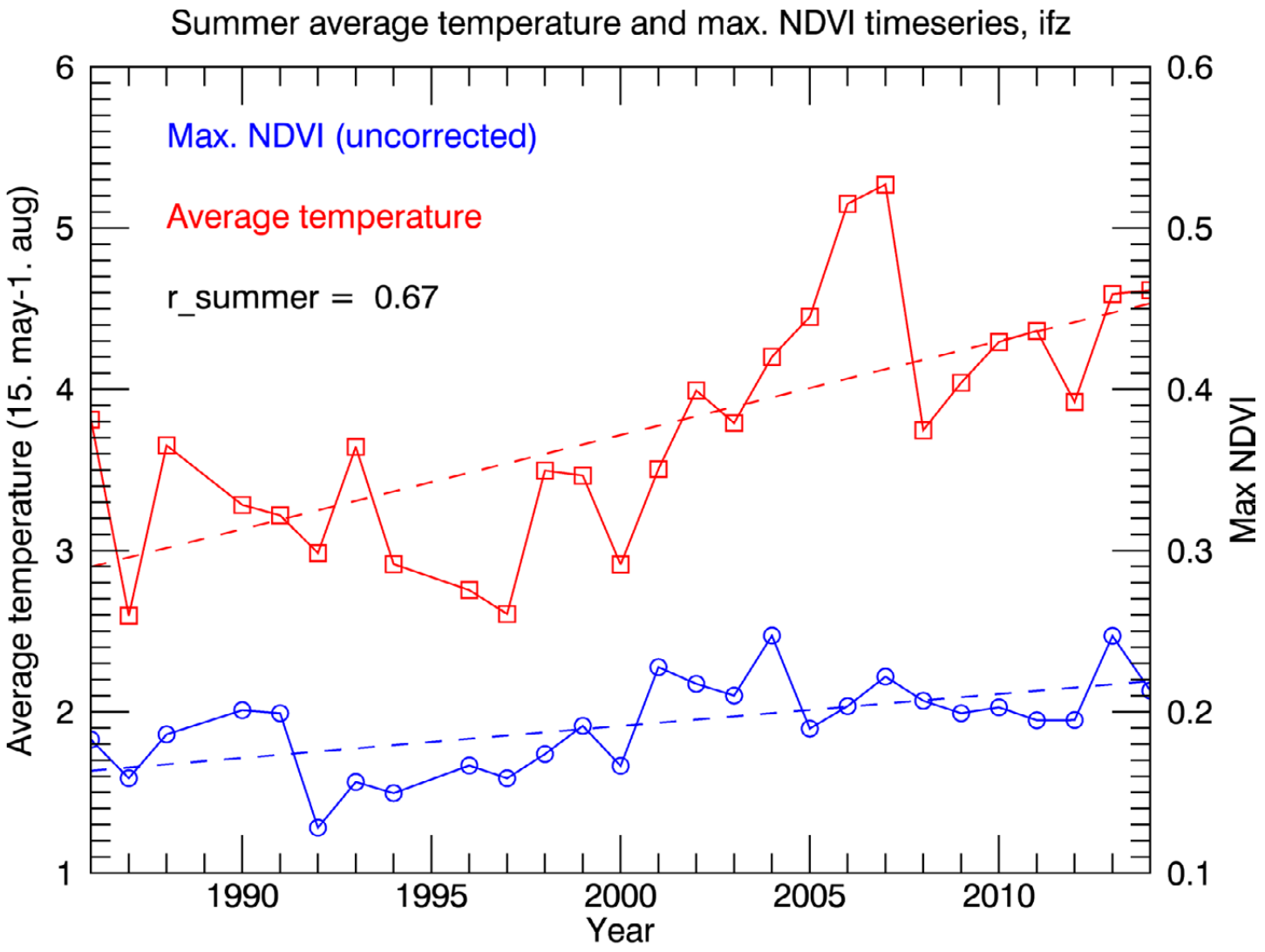



Summer average temperature and max. NDVI timeseries, ifz
Max. NDVI (uncorrected)
Average temperature
r_summer = 0.58
Average temperature (15. may-1. aug)
Max NDVI
Year
1
2
3
4
5
6
0.1
0.2
0.3
0.4
0.5
0.6
1990
1995
2000
2005
2010

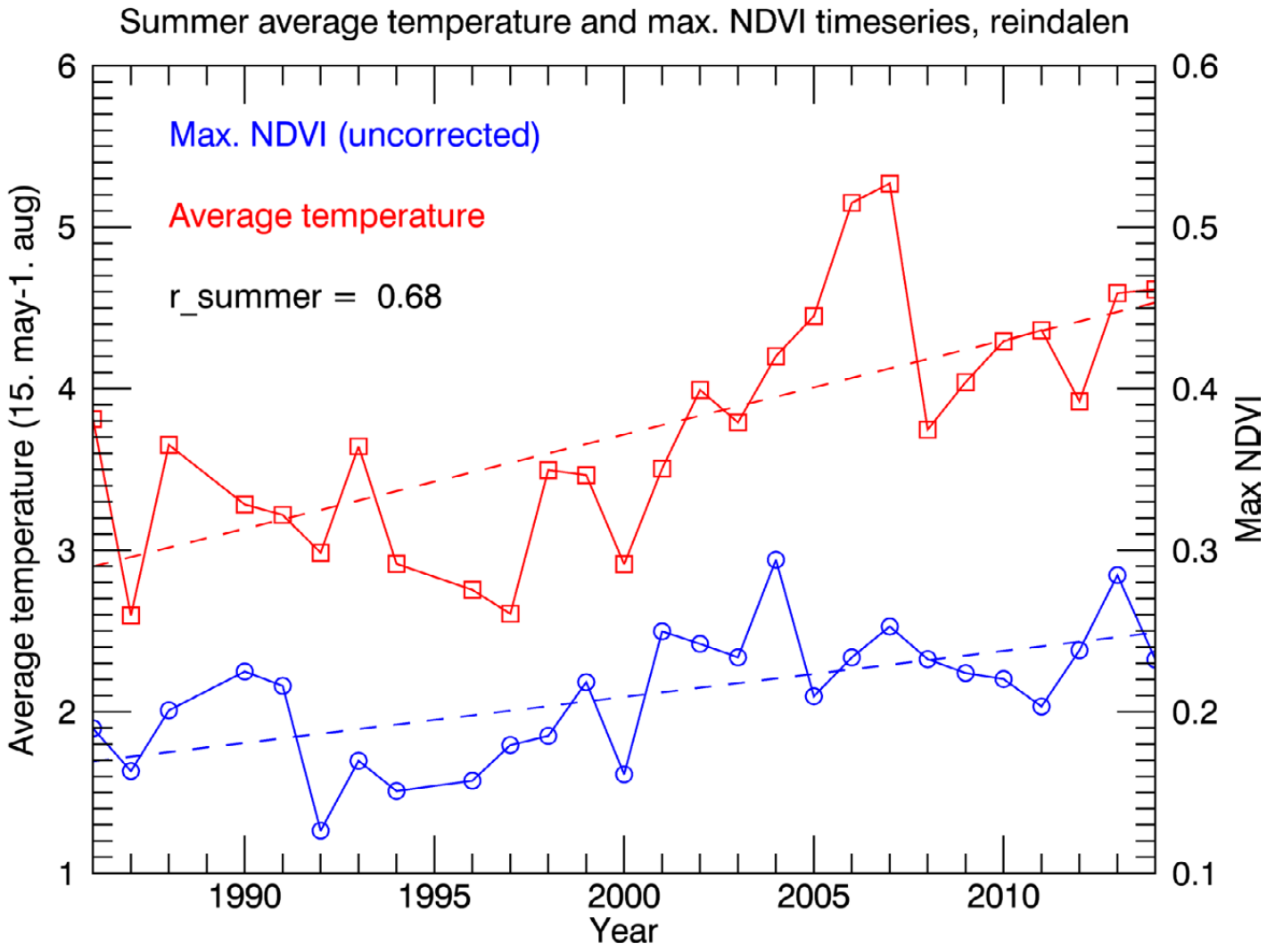

Summer average temperature and max. NDVI timeseries, reindalen
Max. NDVI (uncorrected)
Average temperature
r_summer = 0.59
Average temperature (15. may-1. aug)
Max NDVI
Year
1
2
3
4
5
6
0.1
0.2
0.3
0.4
0.5
0.6
1990
1995
2000
2005
2010


Max. NDVI (uncorr) vs. temperature
r_summer = 0.60
Max. yearly NDVI (IFZ)
0.30
0.25
0.20
0.15
0.10
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Summer average temperature

Without 1989 and 1995



Without 1989 og 1995



Summary

- We now have a 1986-2014 NDVI dataset over Svalbard
- We have a correlation between spring/summer temperature and max NDVI value
- We see a 1.6 degree spring/summer warming trend
- We see a 0.08 increasing trend in the max NDVI value during the periode (greening)
- Will also include 2015