Characterization of Terrestrial Water Dynamics in the Congo Basin using GRACE and Satellite Radar Altimetry

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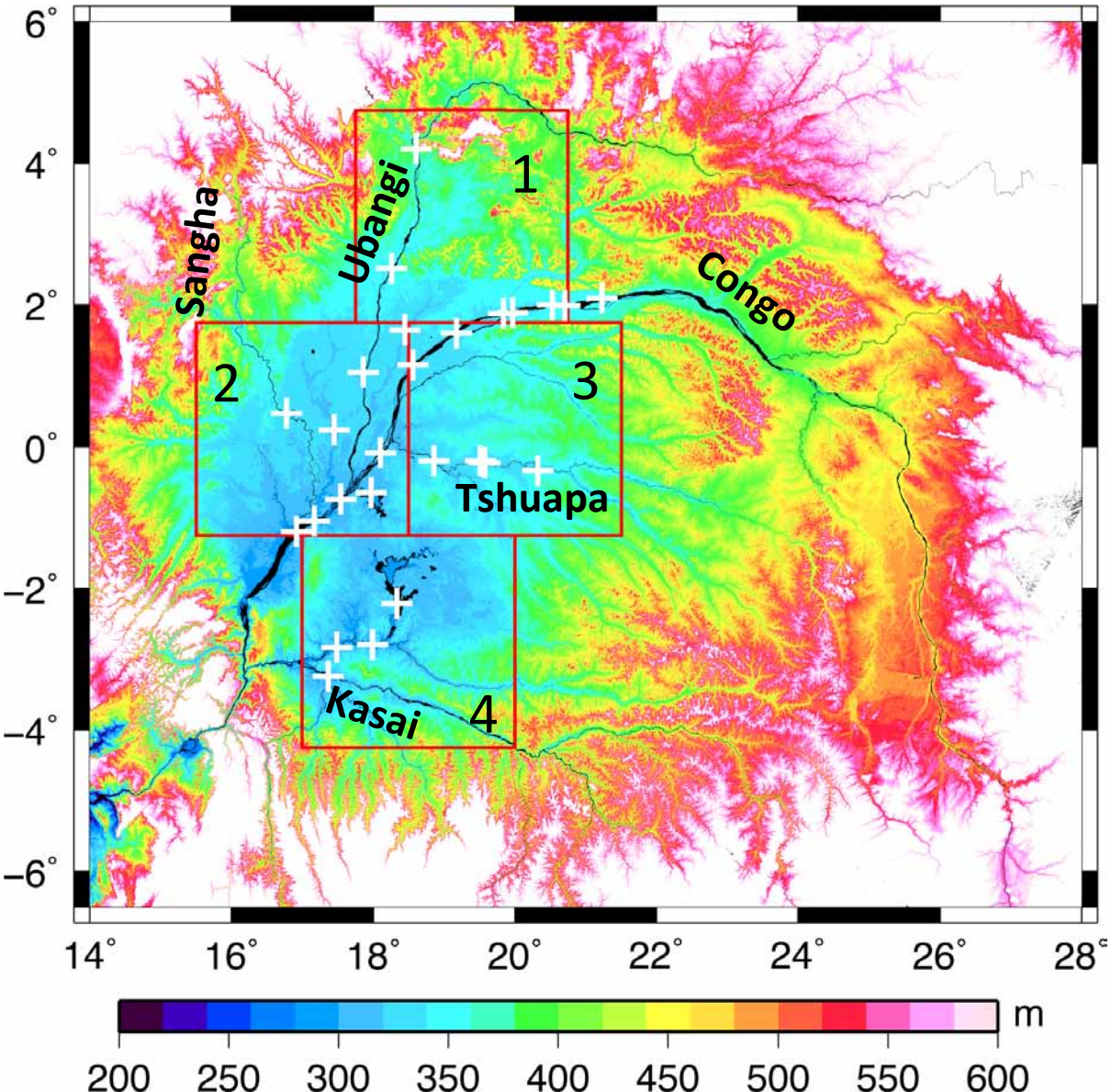
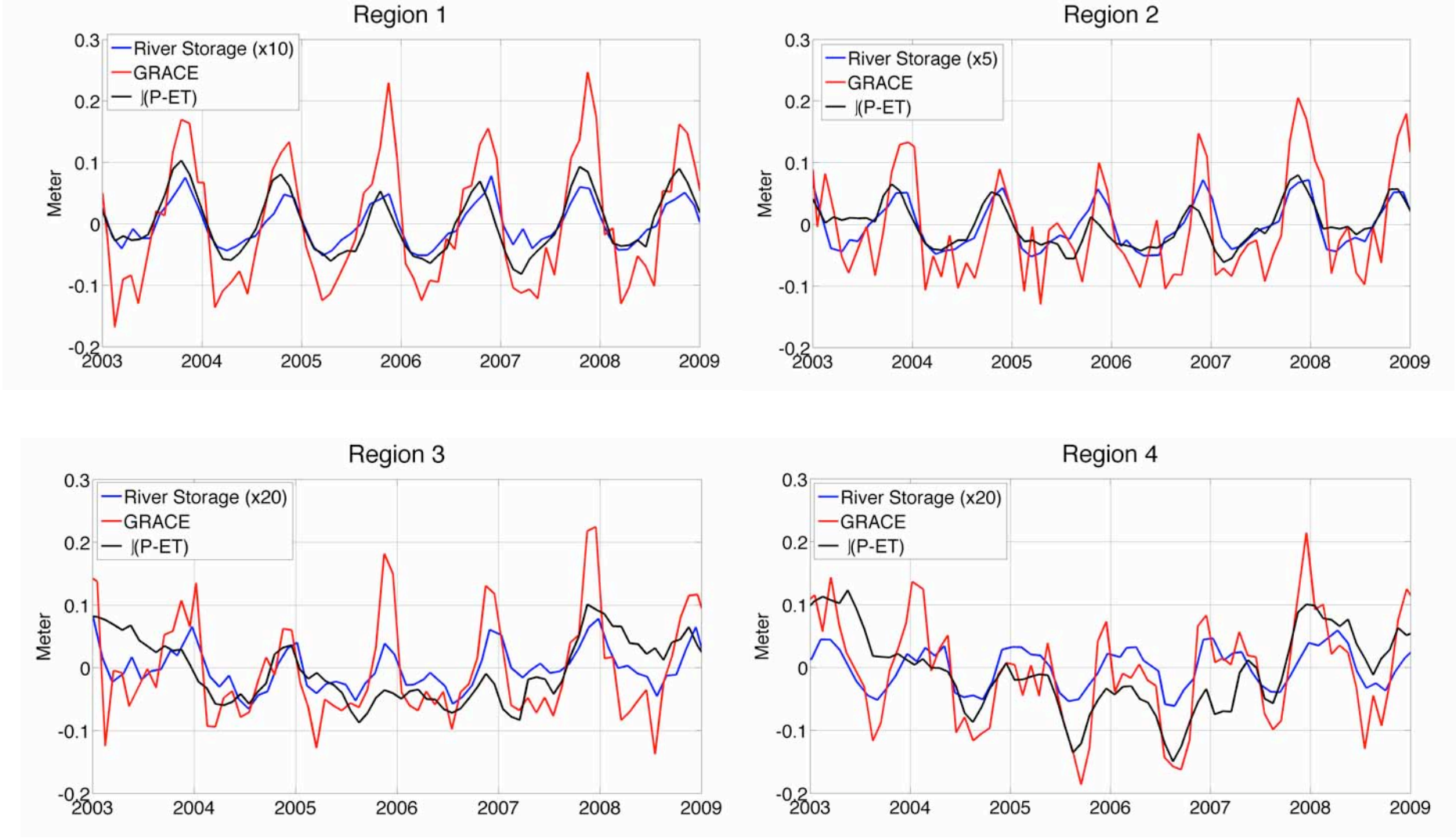
Introduction

- Congo Basin – world's third largest in size (3.7 million km^2) with the Congo River second only to the Amazon River in discharge (40,000 m^3/s) – lack of in situ measurements
- Question – how much water is on the Congo wetlands and where does the water come from?
- Datasets
  - Total storage anomalies from GRACE
  - River stage anomalies from Envisat altimeter and GRFM
  - Precipitation from GPCP
  - ET from Hillslope River Routing (HRR) model (Beighley et al., 2009)
  - Land-cover classifications from GRFM mosaic, SRTM and MODIS mosaic (for details, Jung et al. H33K-03)

Congo Wetlands



Satellite Measurements of Congo Hydrology



Wetland Storage Changes

$$\Delta S = \Delta Sg + \Delta Sr + \Delta Sw$$

Total storage anomalies from GRACE

Groundwater storage anomalies (Assumed negligible, based on Laraque et al., 2001)

River storage anomalies from altimeter and open water area from GRFM mosaic

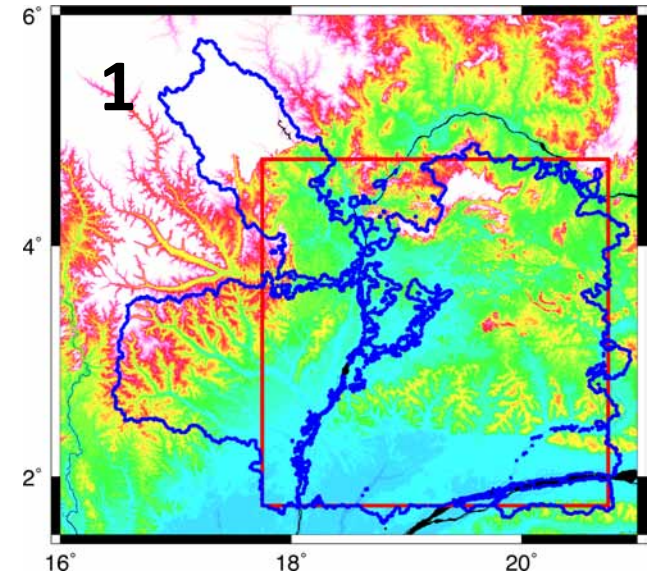
Wetland storage anomalies

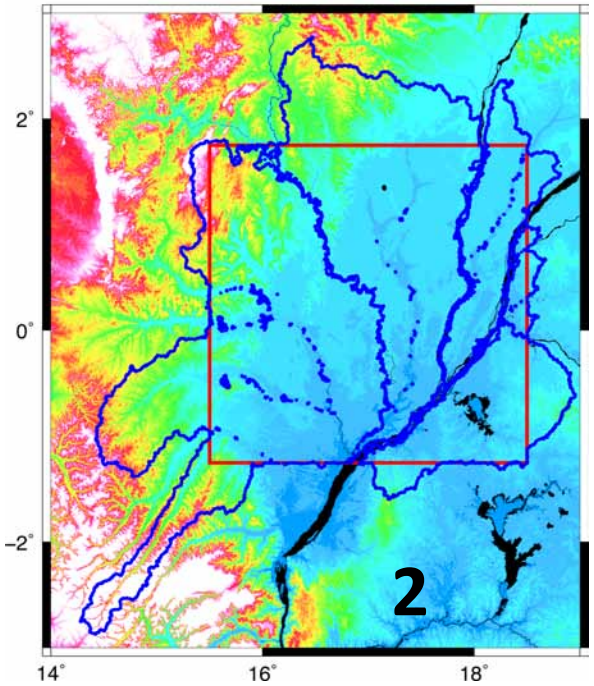
$$\Delta Sw = Rup - Qf$$

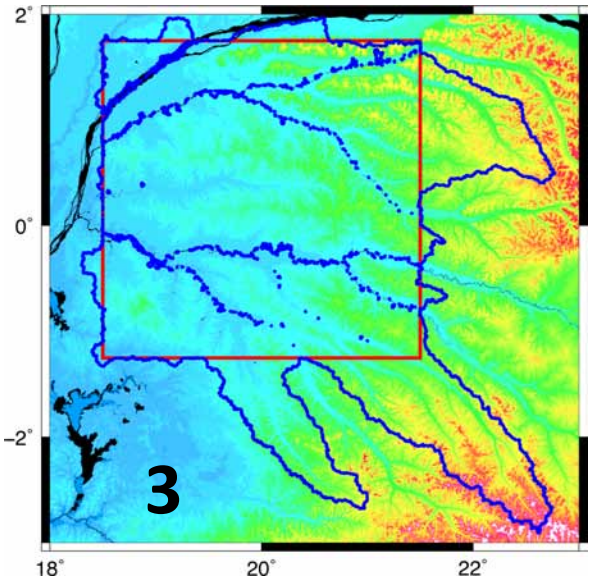
Runoff from uplands (& direct rainfall on wetlands), approximated by P-ET anomalies multiplied by the contributing area

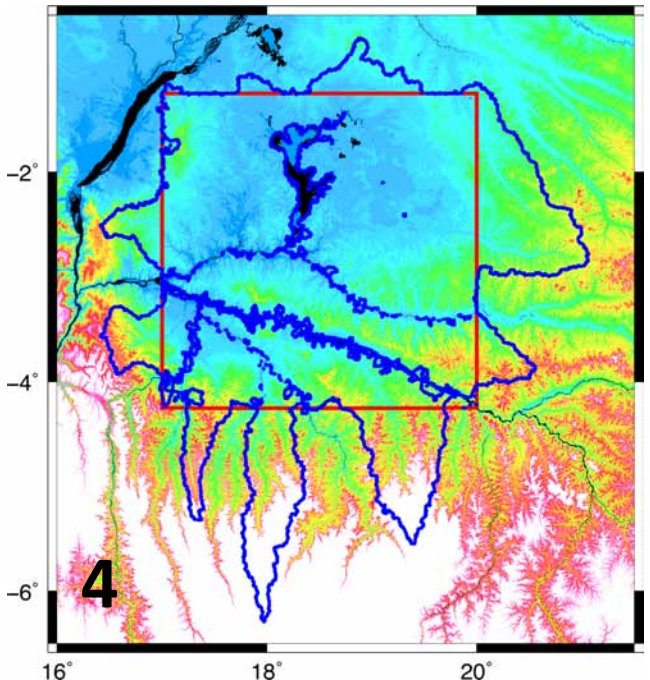
Flux to river

Contributing area to the wetlands

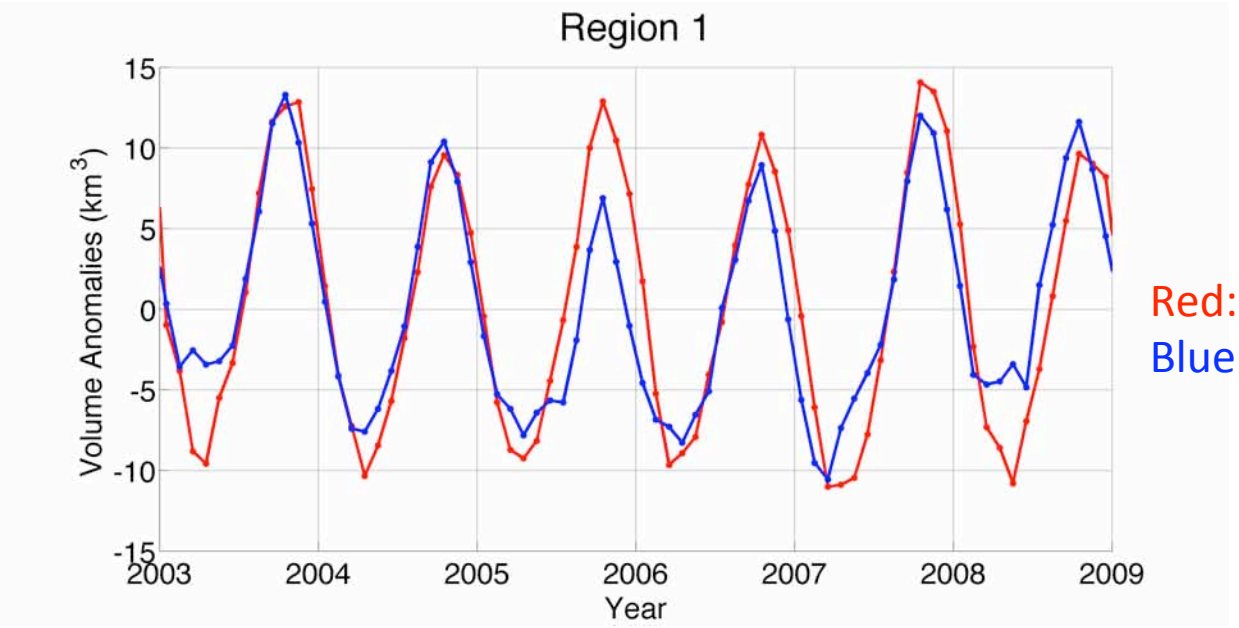








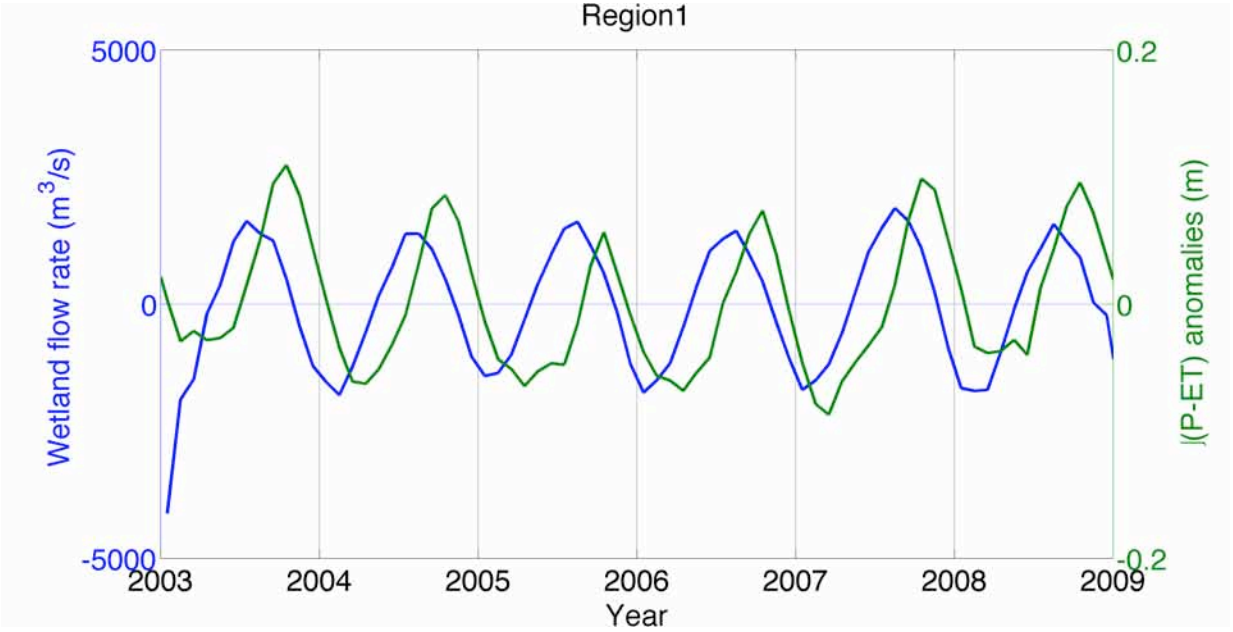
1) Flow directions from SRTM DEM
2) Remove major rivers draining > 10,000 km^2
3) Extract wetland pixels for each box
4) Delineate the watershed to each wetland pixel

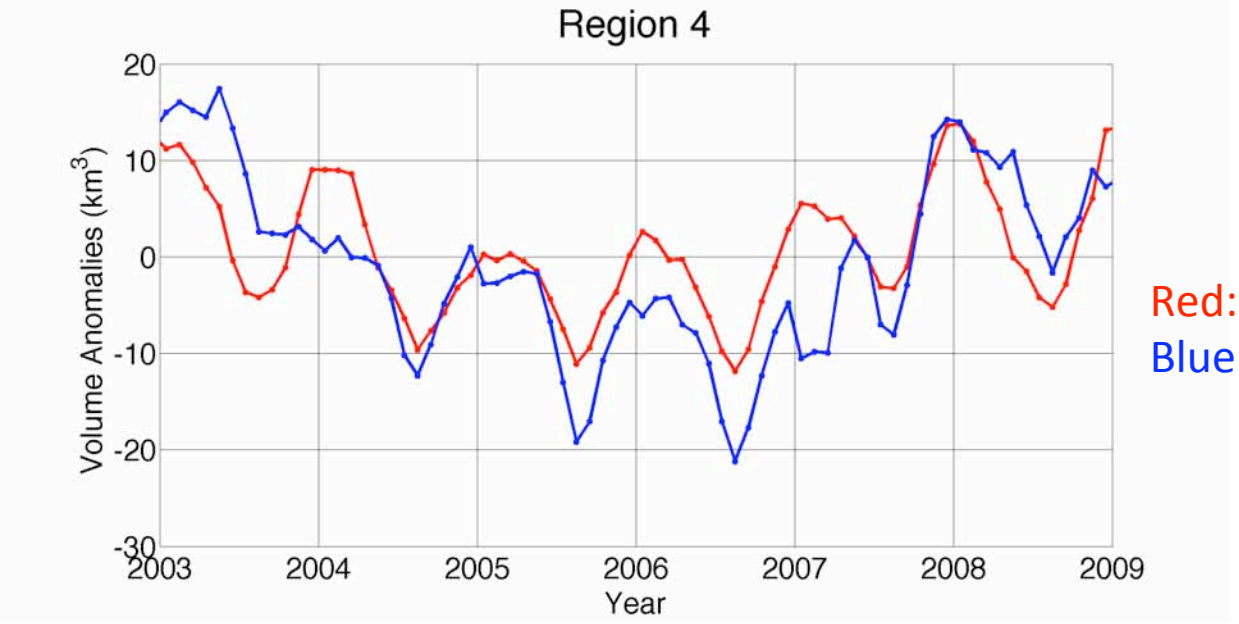


Red: Total wetland storage anomalies

Blue: Contribution from runoff

Wetland discharge and P-ET





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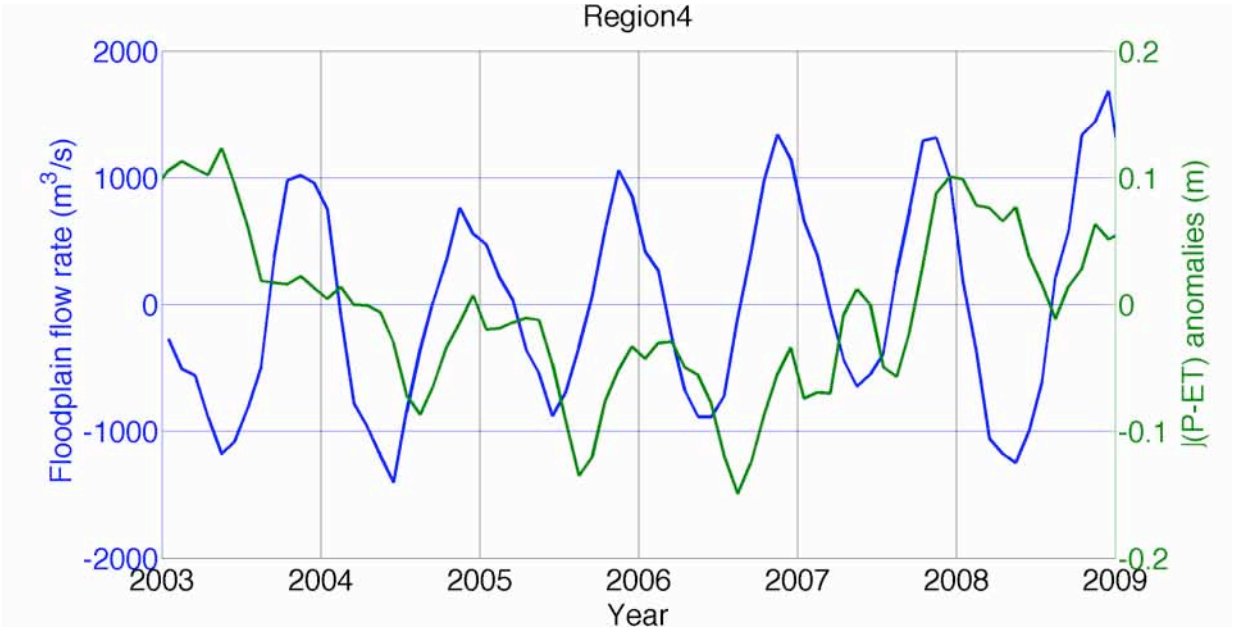
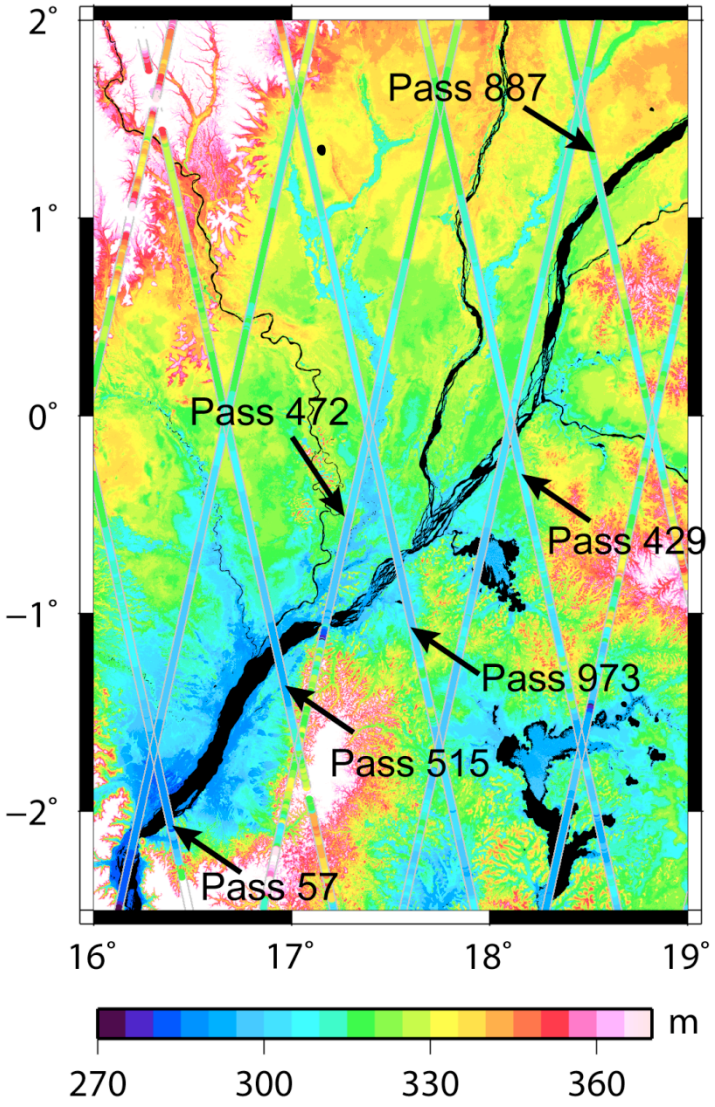
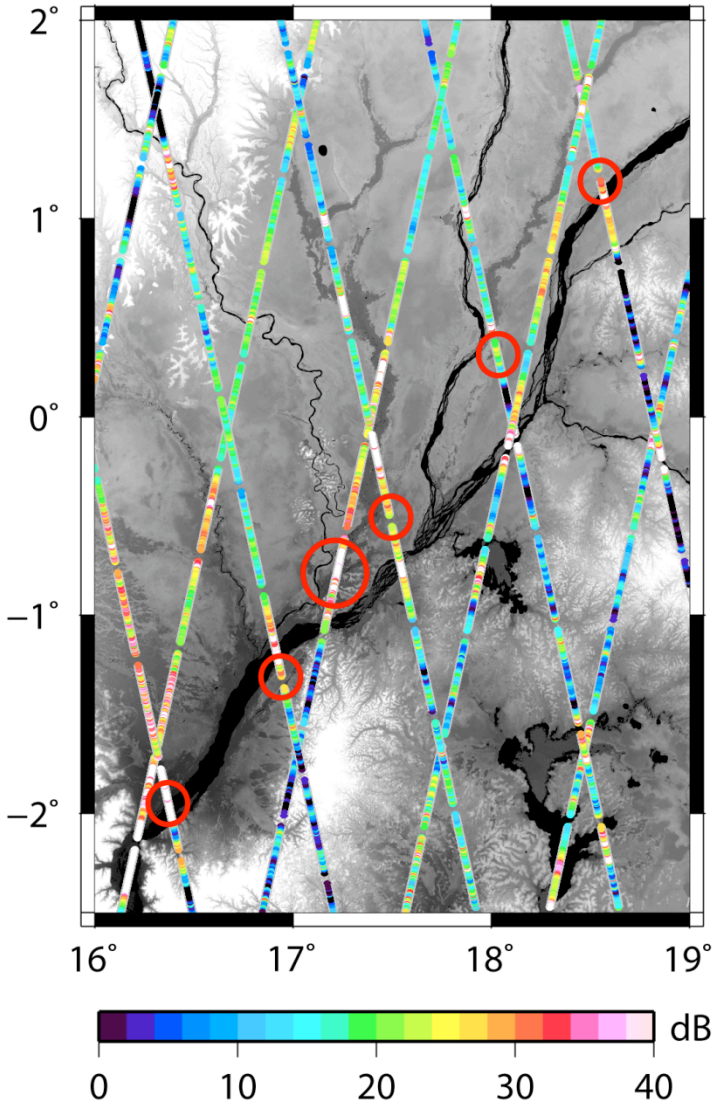
Wetland discharge and P-ET



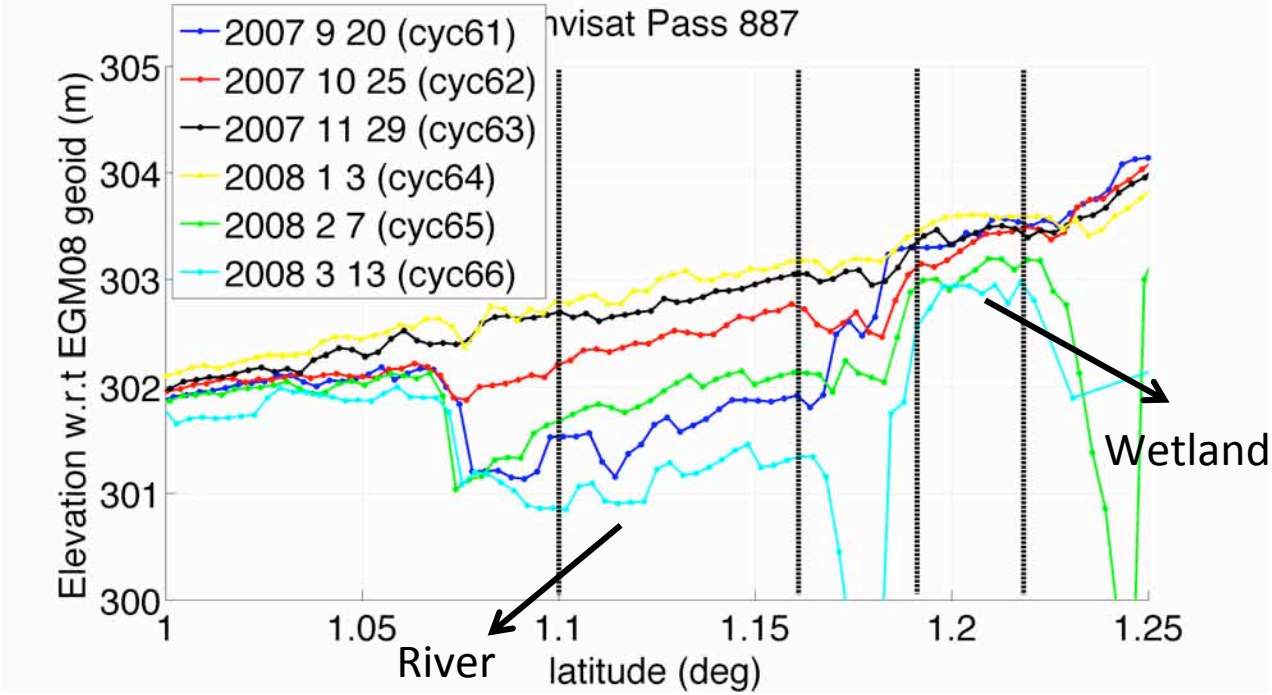
Envisat Altimeter over Congo Basin

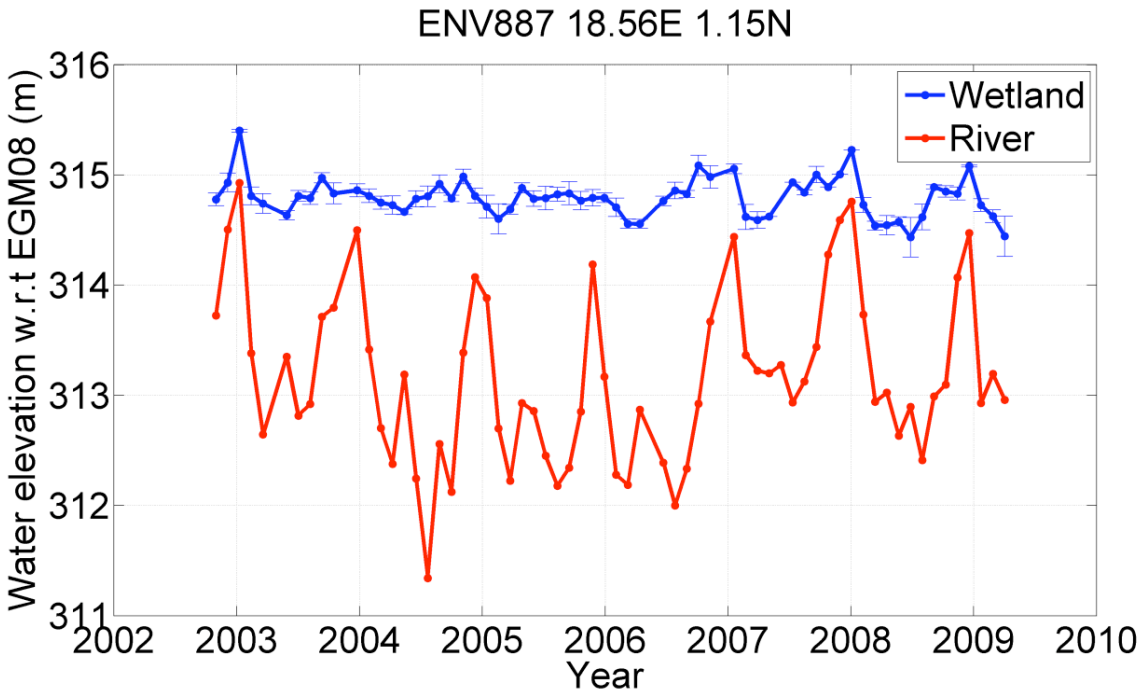


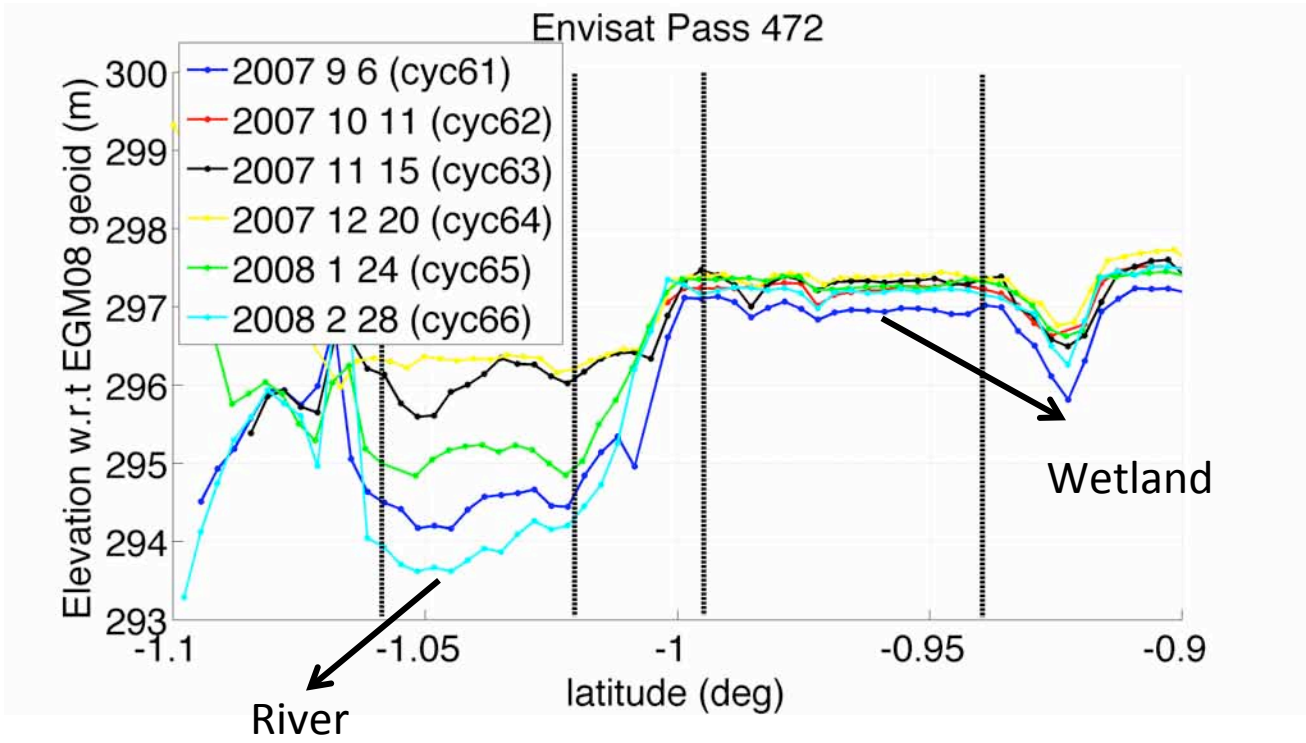
Retracked Surface Heights

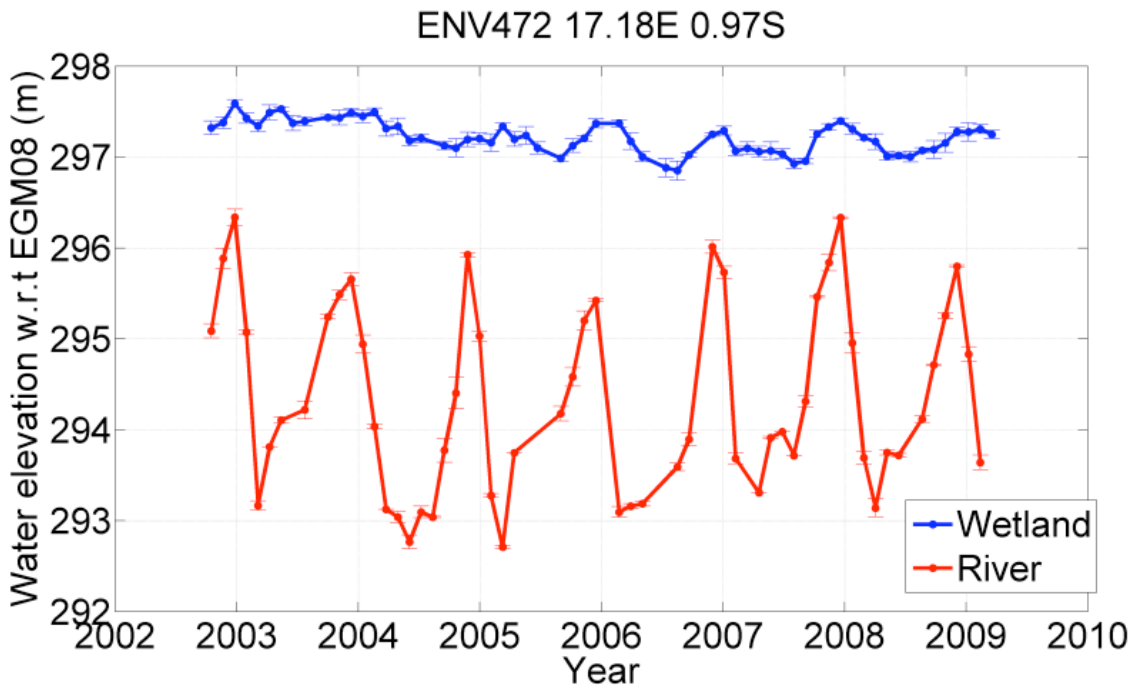


Backscattering coefficients

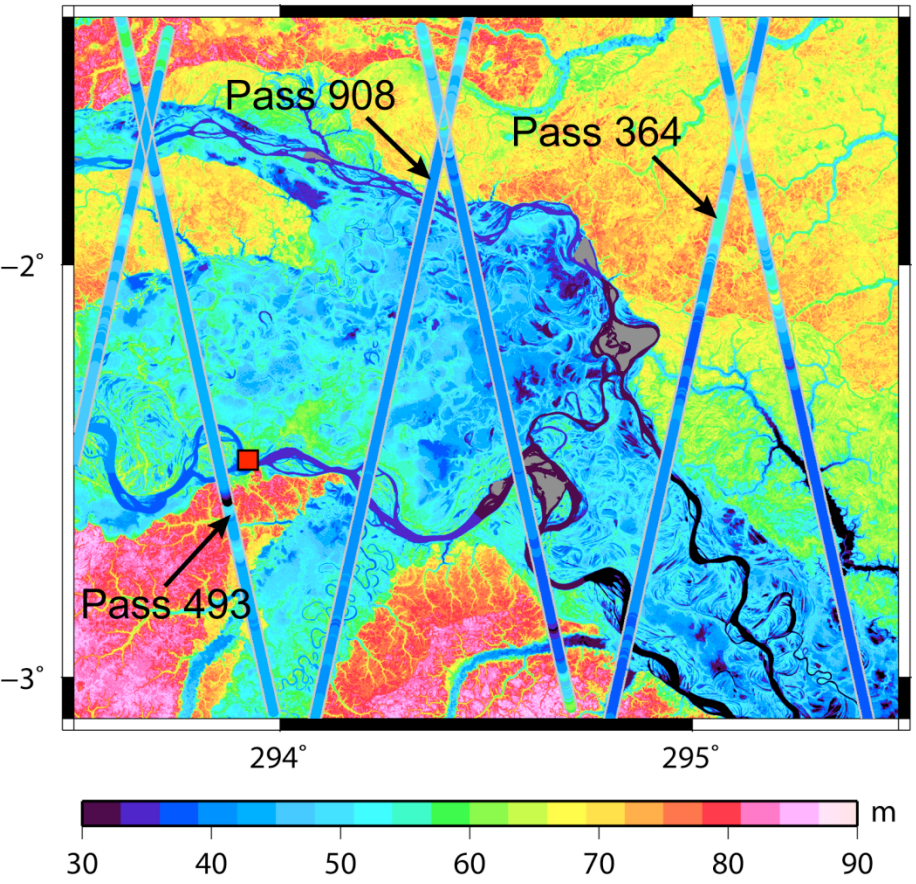

nvisat Pass 887
2007 9 20 (cyc61)
2007 10 25 (cyc62)
2007 11 29 (cyc63)
2008 1 3 (cyc64)
2008 2 7 (cyc65)
2008 3 13 (cyc66)
Elevation w.r.t EGM08 geoid (m)
305
304
303
302
301
300
1
1.05
1.1
1.15
1.2
1.25
latitude (deg)
River
Wetland


ENV887 18.56E 1.15N
Water elevation w.r.t EGM08 (m)
316
315
314
313
312
311
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Wetland
River

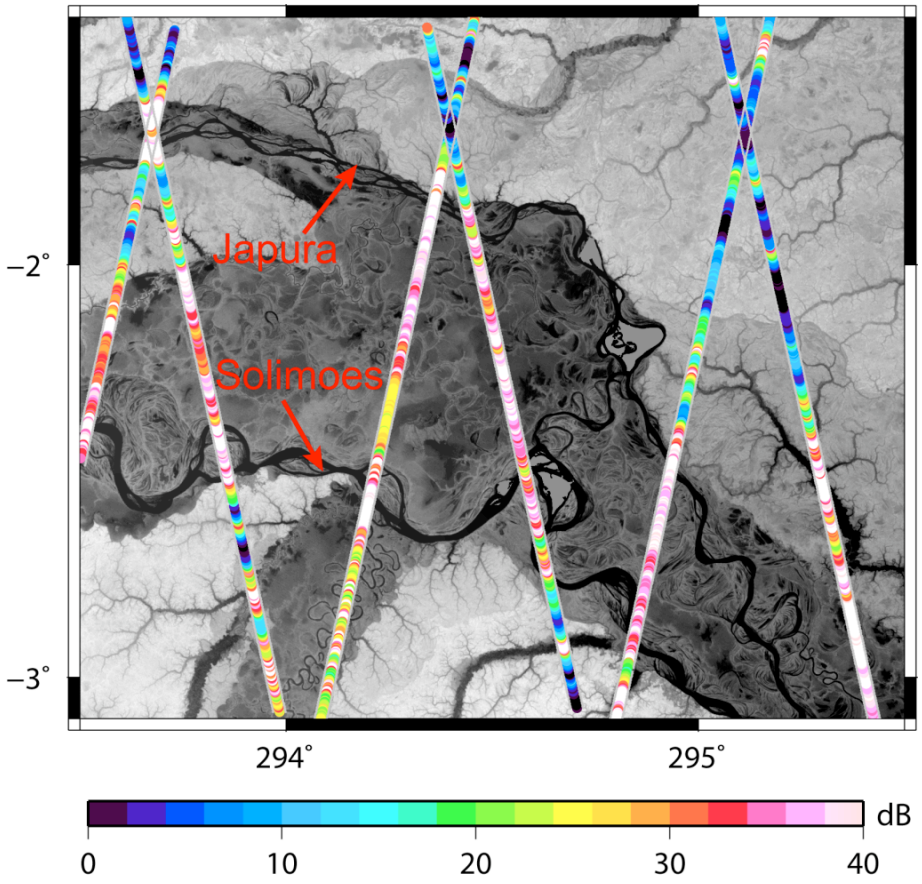

Envisat Pass 472
2007 9 6 (cyc61)
2007 10 11 (cyc62)
2007 11 15 (cyc63)
2007 12 20 (cyc64)
2008 1 24 (cyc65)
2008 2 28 (cyc66)
Elevation w.r.t EGM08 geoid (m)
300
299
298
297
296
295
294
293
-1.1
-1.05
-1
-0.95
-0.9
latitude (deg)
Wetland
River


ENV472 17.18E 0.97S
Water elevation w.r.t EGM08 (m)
298
297
296
295
294
293
292
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Wetland
River

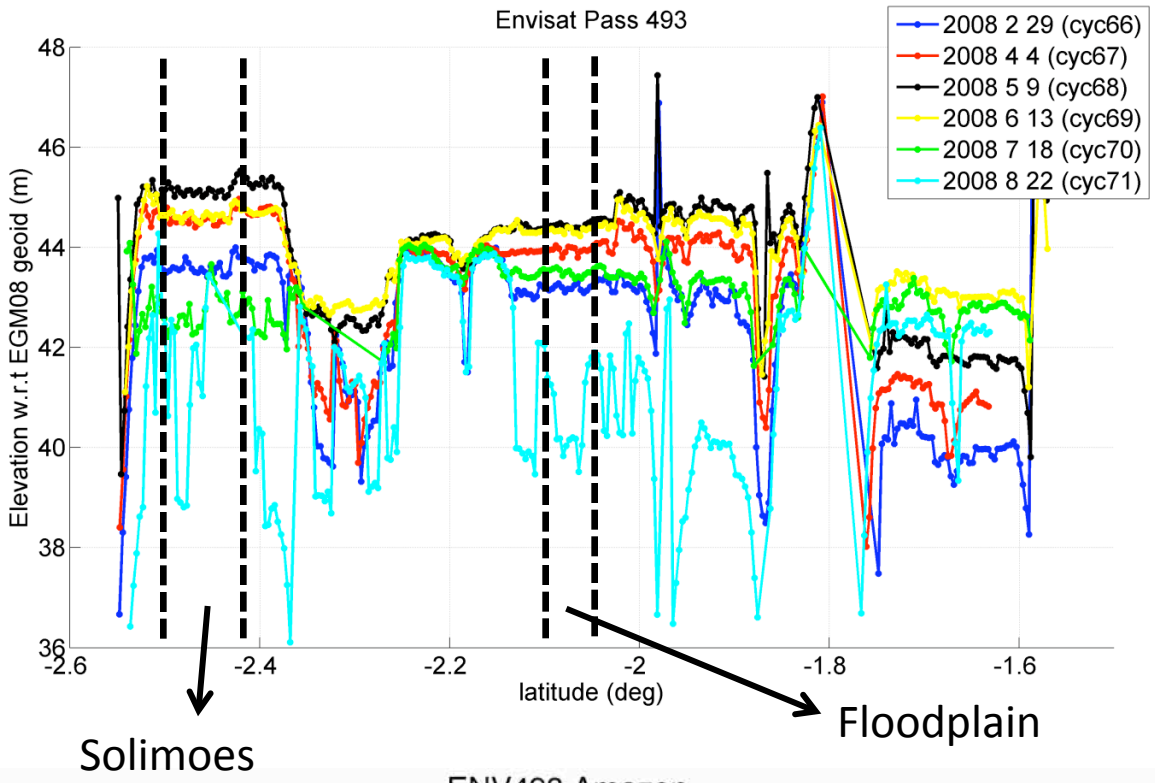
Envisat Altimeter over Amazon Basin

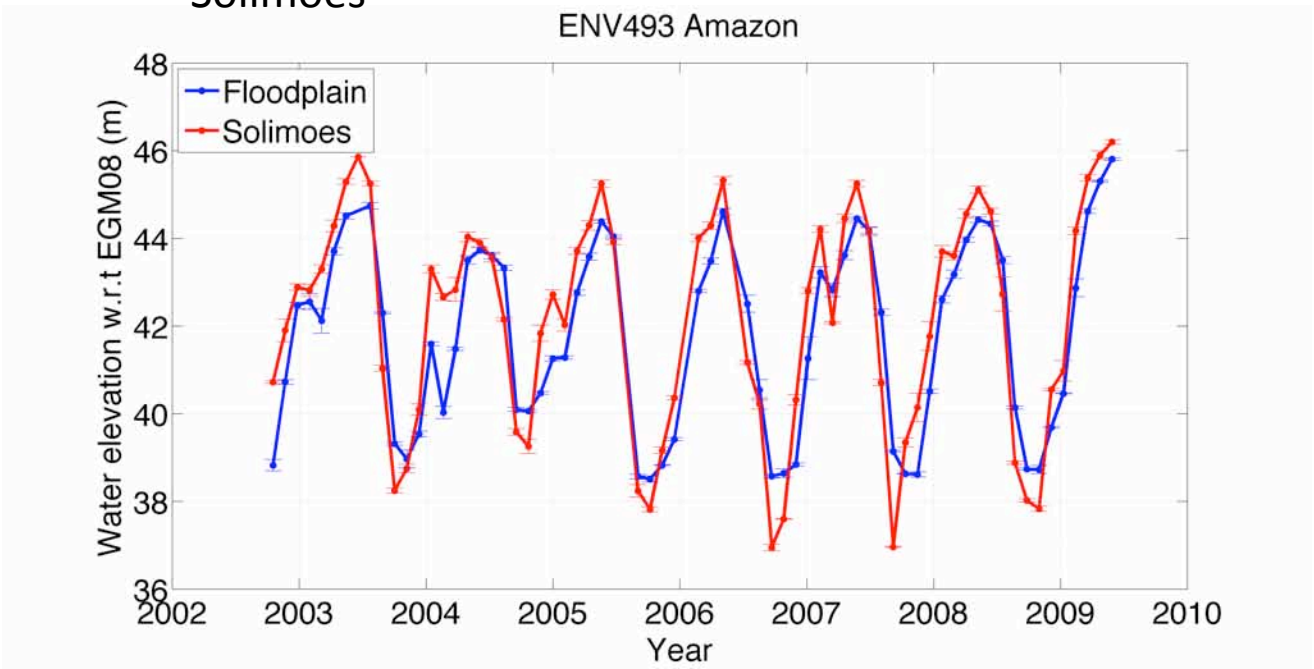


Retracked Surface Heights



Backscattering coefficients


Envisat Pass 493
2008 2 29 (cyc66)
2008 4 4 (cyc67)
2008 5 9 (cyc68)
2008 6 13 (cyc69)
2008 7 18 (cyc70)
2008 8 22 (cyc71)
Elevation w.r.t EGM08 geoid (m)
48
46
44
42
40
38
36
-2.6
-2.4
-2.2
-2
-1.8
-1.6
latitude (deg)
Solimoes
Floodplain


ENV493 Amazon
Floodplain
Solimoes
Water elevation w.r.t EGM08 (m)
48
46
44
42
40
38
36
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

Conclusions

- In contrast to Amazon, where floodplain storage change is dominated by river exchange, in Congo, wetlands fill because of P-ET runoff and empty from a combination of drainage to the river and the lack of rainfall.
- Amount of water stored on and drained from the Congo wetlands represents about 8% of water volume discharged from the Congo River near its mouth (historic Kinshasa gauge).
- Wetland water flux rates vary from 1890 m^3/s during infilling to -1890 m^3/s during drainage.