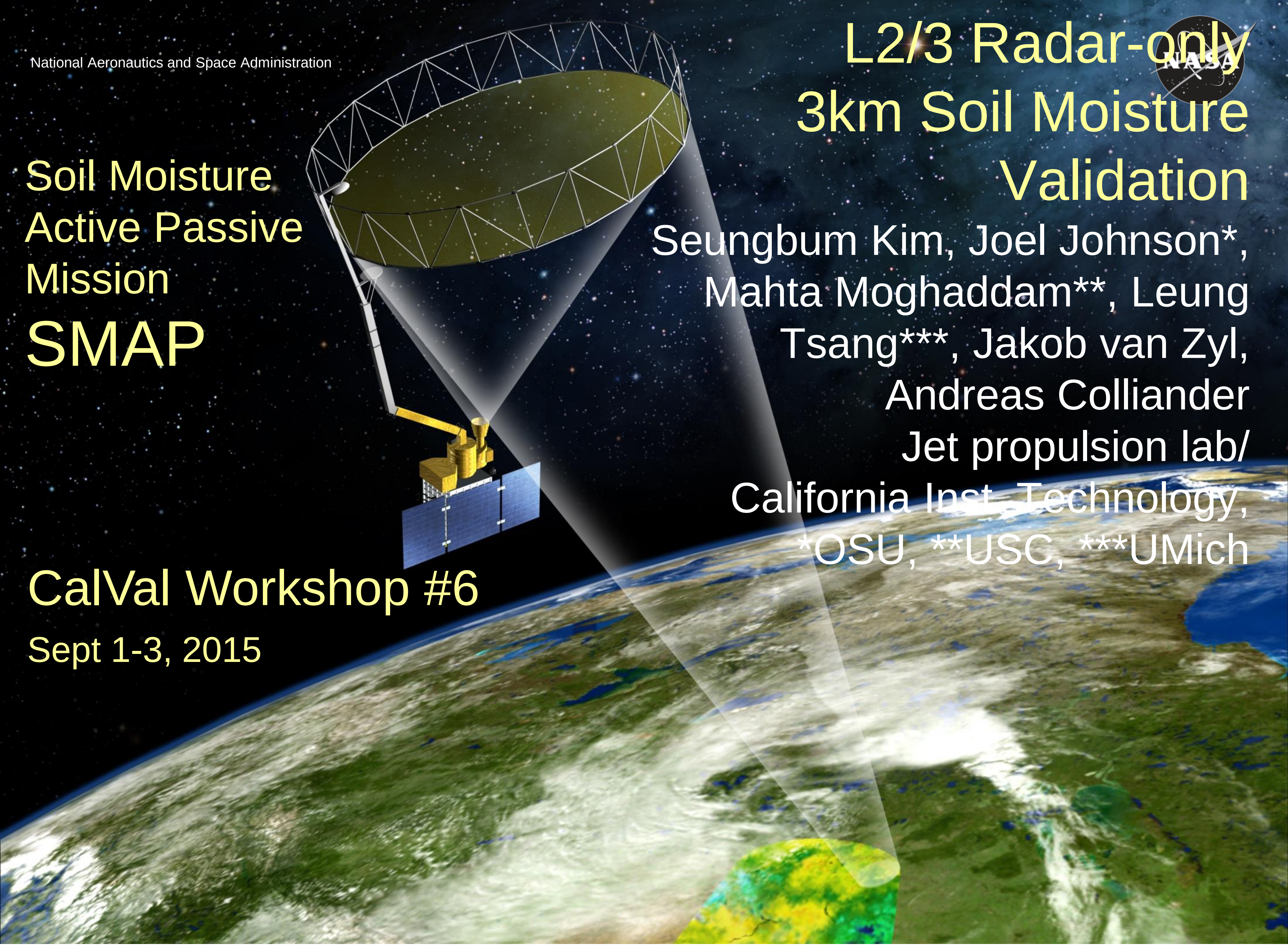

National Aeronautics and Space Administration

# L2/3 Radar-only 3km Soil Moisture Validation

Soil Moisture Active Passive Mission

SMAP

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CalVal Workshop #6

Sept 1-3, 2015

# 3km soil moisture retrieval algorithms

- Baseline [Kim et al. 2014]
  - Inversion of a radar forward model (overbar denotes parameters to retrieve).

$$
\begin{aligned}
&C(\bar{s}, \bar{\varepsilon}_{r1}, \bar{\varepsilon}_{r2}, \ldots, \bar{\varepsilon}_{rN}) = \\
&w_{1,HH}(\sigma^0_{HH,1} - \sigma^0_{HH,fwd}(\bar{s}, \bar{\varepsilon}_{r1}, VWC_1) + \bar{c})^2 + w_{1,VV}(\sigma^0_{VV,1} - \sigma^0_{VV,fwd}(\bar{s}, \bar{\varepsilon}_{r1}, VWC_1) + \bar{c})^2 + \\
&w_{2,HH}(\sigma^0_{HH,2} - \sigma^0_{HH,fwd}(\bar{s}, \bar{\varepsilon}_{r2}, VWC_2) + \bar{c})^2 + w_{2,VV}(\sigma^0_{VV,2} - \sigma^0_{VV,fwd}(\bar{s}, \bar{\varepsilon}_{r2}, VWC_2) + \bar{c})^2 + \ldots. + \\
&w_{N,HH}(\sigma^0_{HH,N} - \sigma^0_{HH,fwd}(\bar{s}, \bar{\varepsilon}_{rN}, VWC_N) + \bar{c})^2 + w_{N,VV}(\sigma^0_{VV,N} - \sigma^0_{VV,fwd}(\bar{s}, \bar{\varepsilon}_{rN}, VWC_N) + \bar{c})^2
\end{aligned}
$$

- Option algorithm II. [Wagner et al. 1999]
  - Relative Change Index

$$
Ms = \frac{(\sigma^{dB}_{VV} - \sigma^{\min,dB}_{VV})}{(\sigma^{\max,dB}_{VV} - \sigma^{\min,dB}_{VV})}
$$

- Option algorithm III [Y.Kim/vanZyl 2009]
  - Currently, Ms*porocity

$$
Mv = C_0 + C_1 \frac{(\sigma^{dB}_{HH} + \sigma^{dB}_{VV})}{2}
$$

- Stand-alone options:
  - Jeff Ouellette, OSU [Mattia et al. 2009]
  - And more

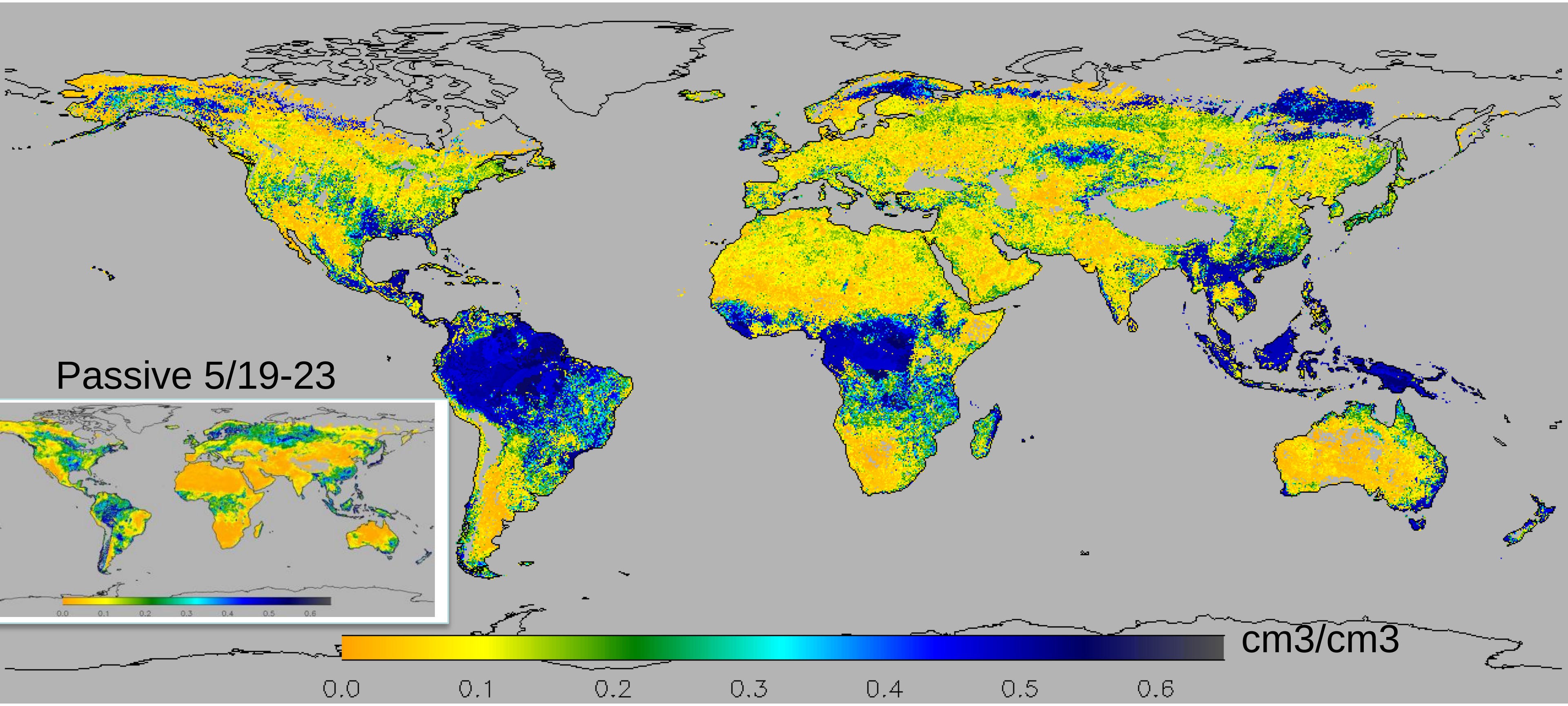
# 3km soil moisture retrieval algorithms

- Major inputs and outputs

| | Input | Output |
|---|---|---|
| Baseline | HH, VV<br>VWC ancillary, HV*<br>Datacubes<br>Landcover map | Soil moisture<br>Surface roughness<br>VWC* |
| Change-index | VV<br>Aquarius-based reference | Change index |
| Change-index-absolute | VV, (optionally) HH<br>Aquarius-based reference<br>Porosity<br>Linear coefficients* | Soil moisture |
| Common | Soil temperature<br>Masks (urban, vegetation, topography, water)<br>Texture | |

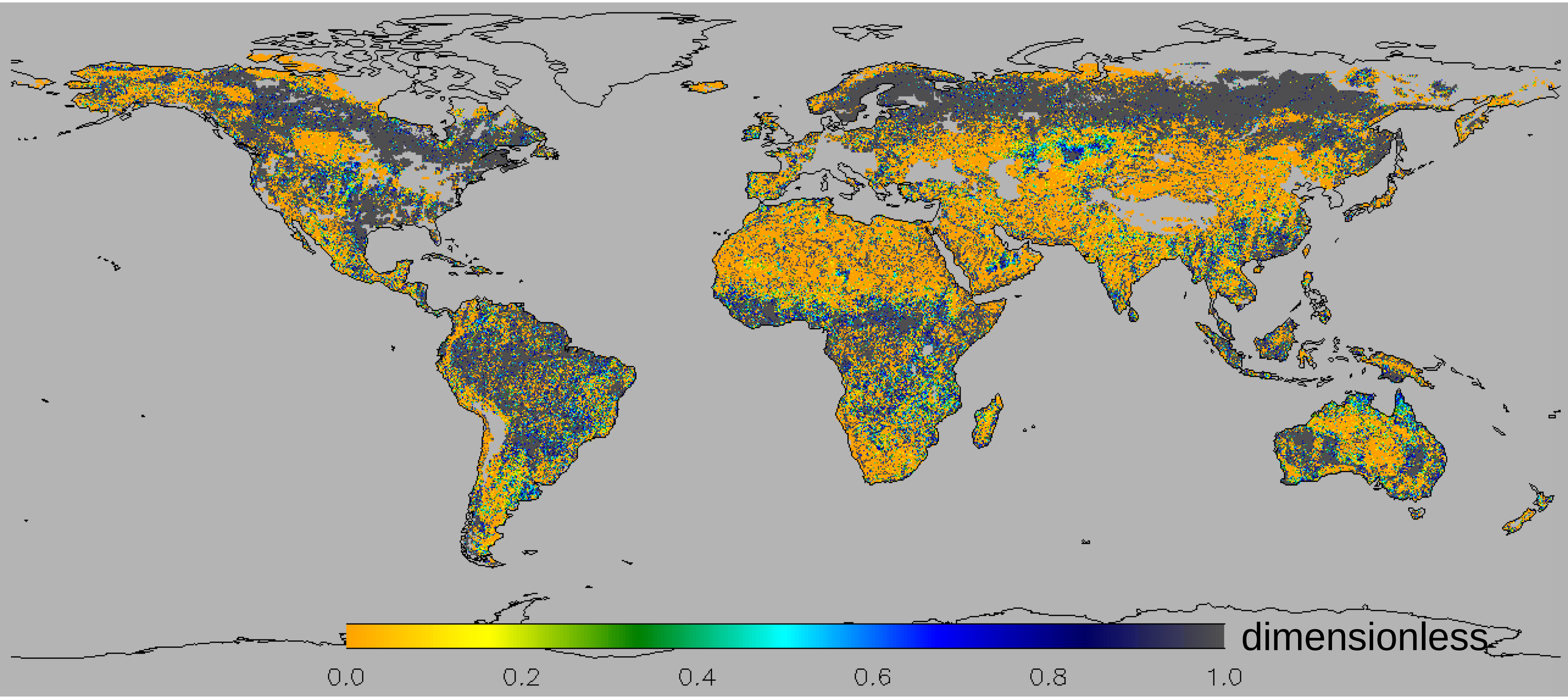
* Not implemented yet

# 3km soil moisture-baseline



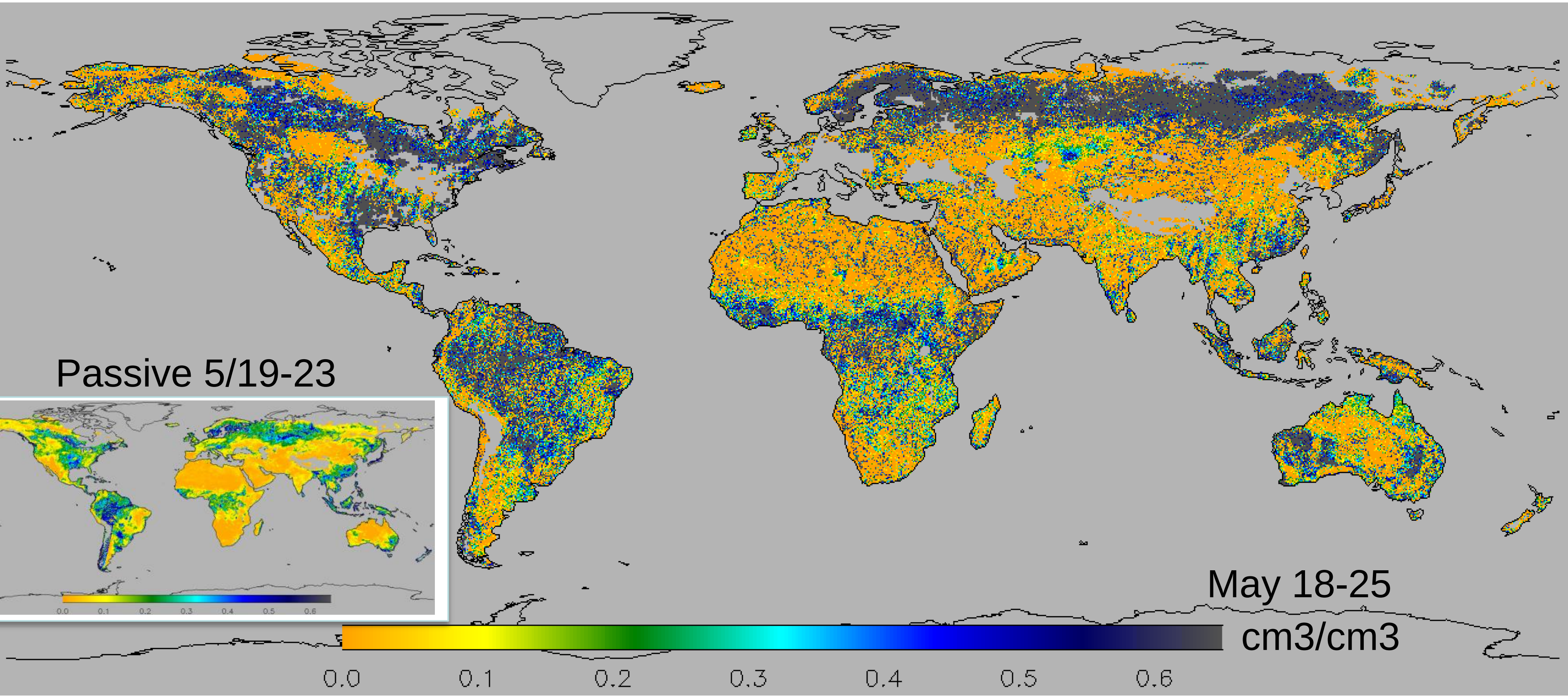

May 18-25 (8 day repeat cycle). Exclude nadir gap.
Success: surface temperature & landcover (ice, snow, static water, urban)

# 3km soil moisture – change index

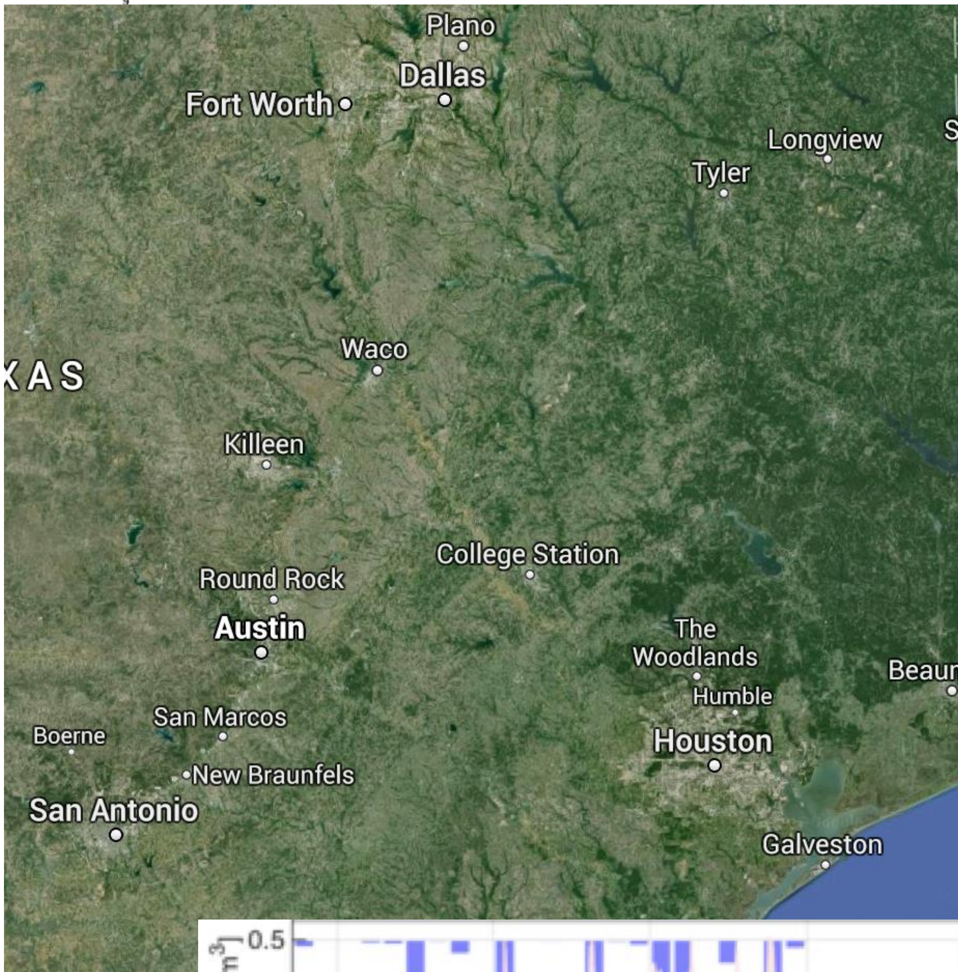


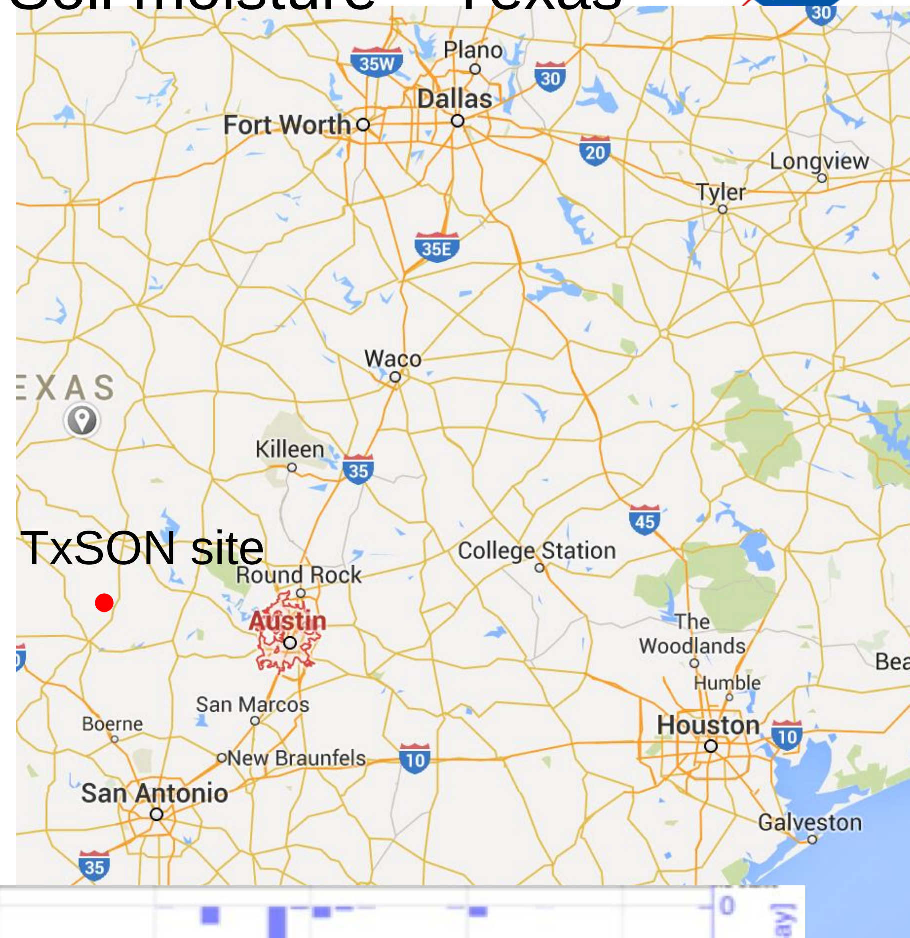

Reference states: 1-year-long Aquaris data (2014)
Gaps in EU and USA are due to the gaps in Aquarius reference (RFI related).

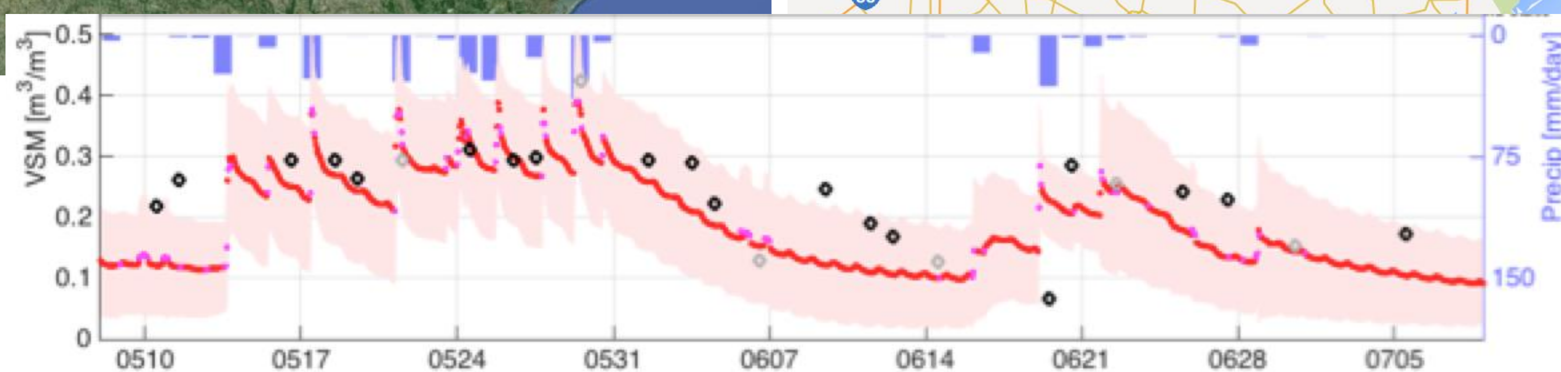
# 3km soil moisture – change index absolute



# Soil moisture – Texas

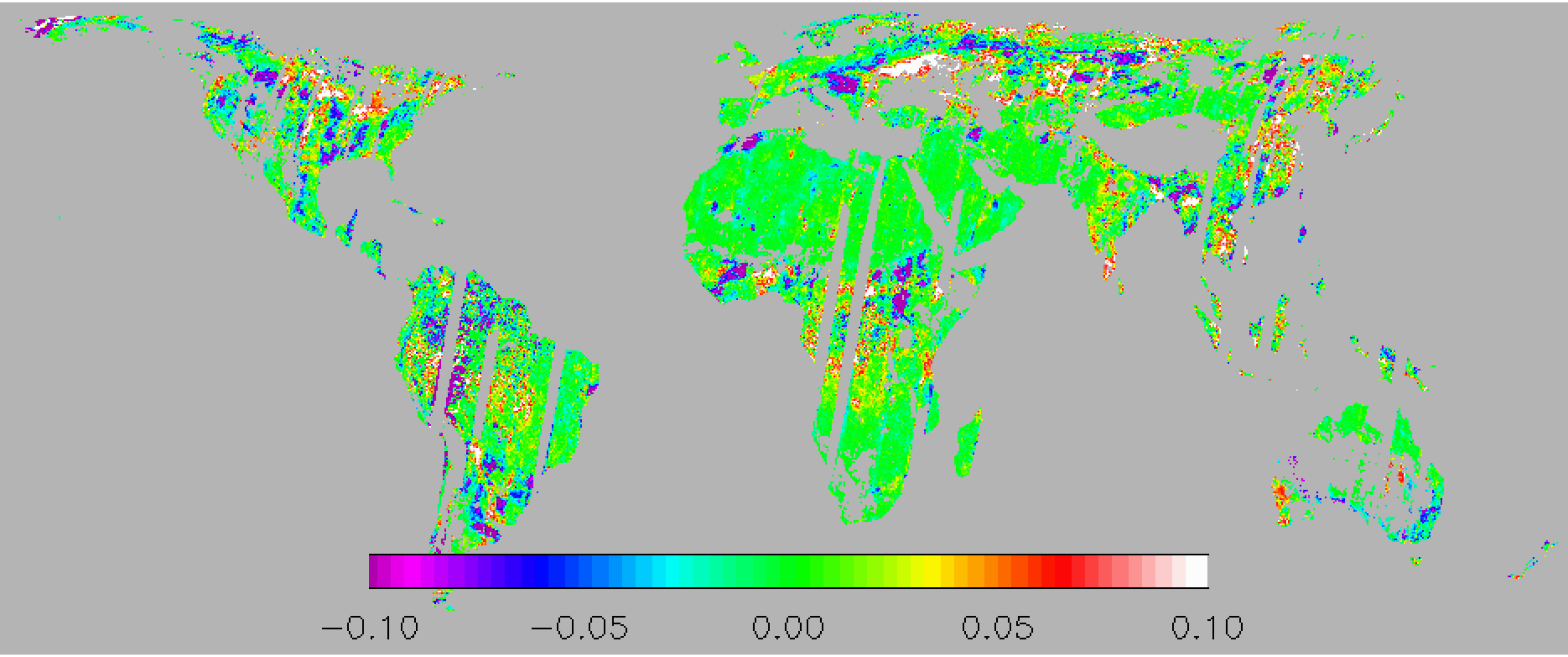


# Active minus Passive (of unbiased anomaly)

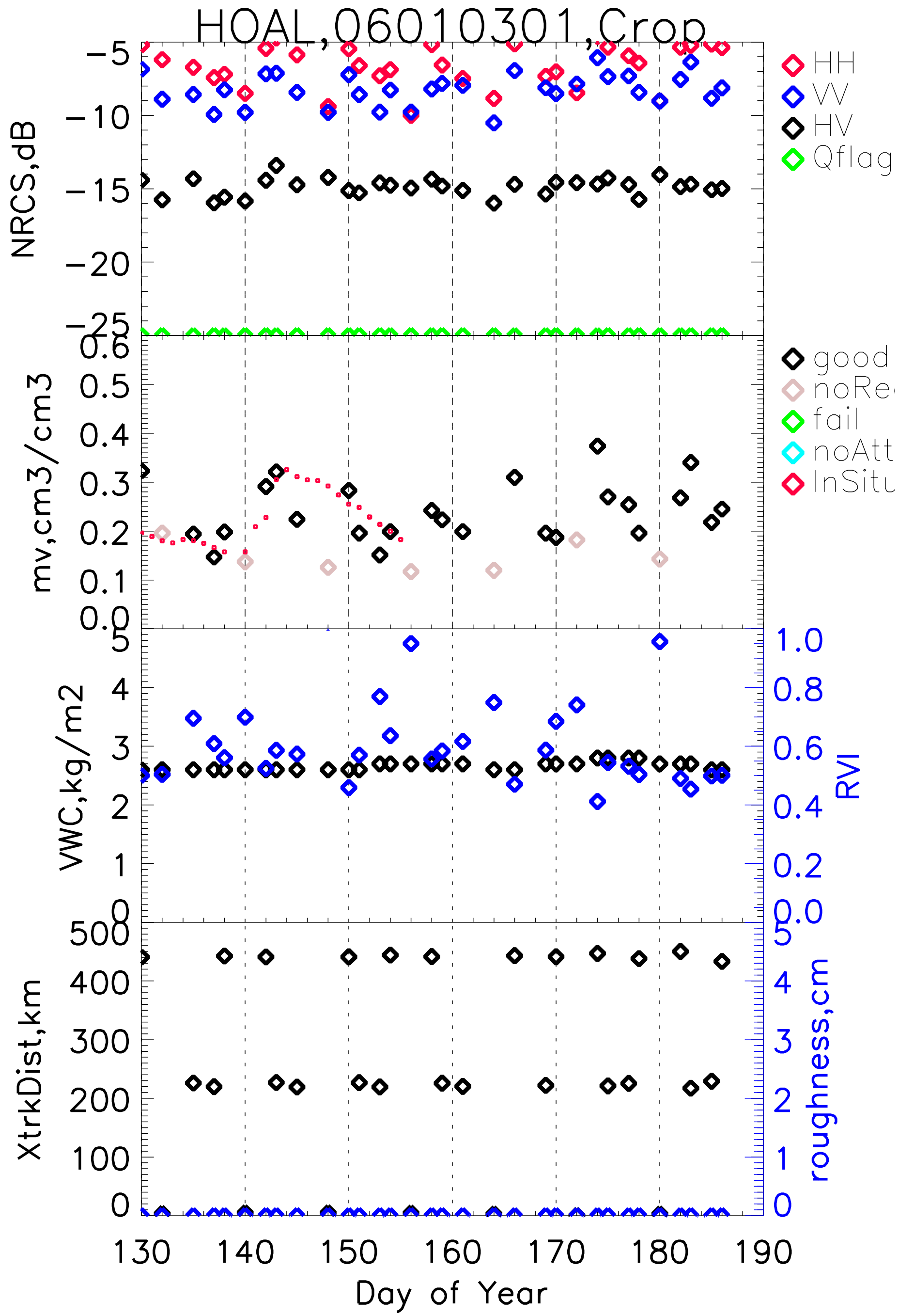
Δ = Active minus Passive
Δ1 (May 10 to 17) = δ1(t) + bias
Δ2 (May 18 to 25) = δ2(t) + bias
Double difference (DD) = (δ1(t) - δ2(t))/√2
Currently only 2 repeat cycle L2SMA is available, so cannot estimate bias.

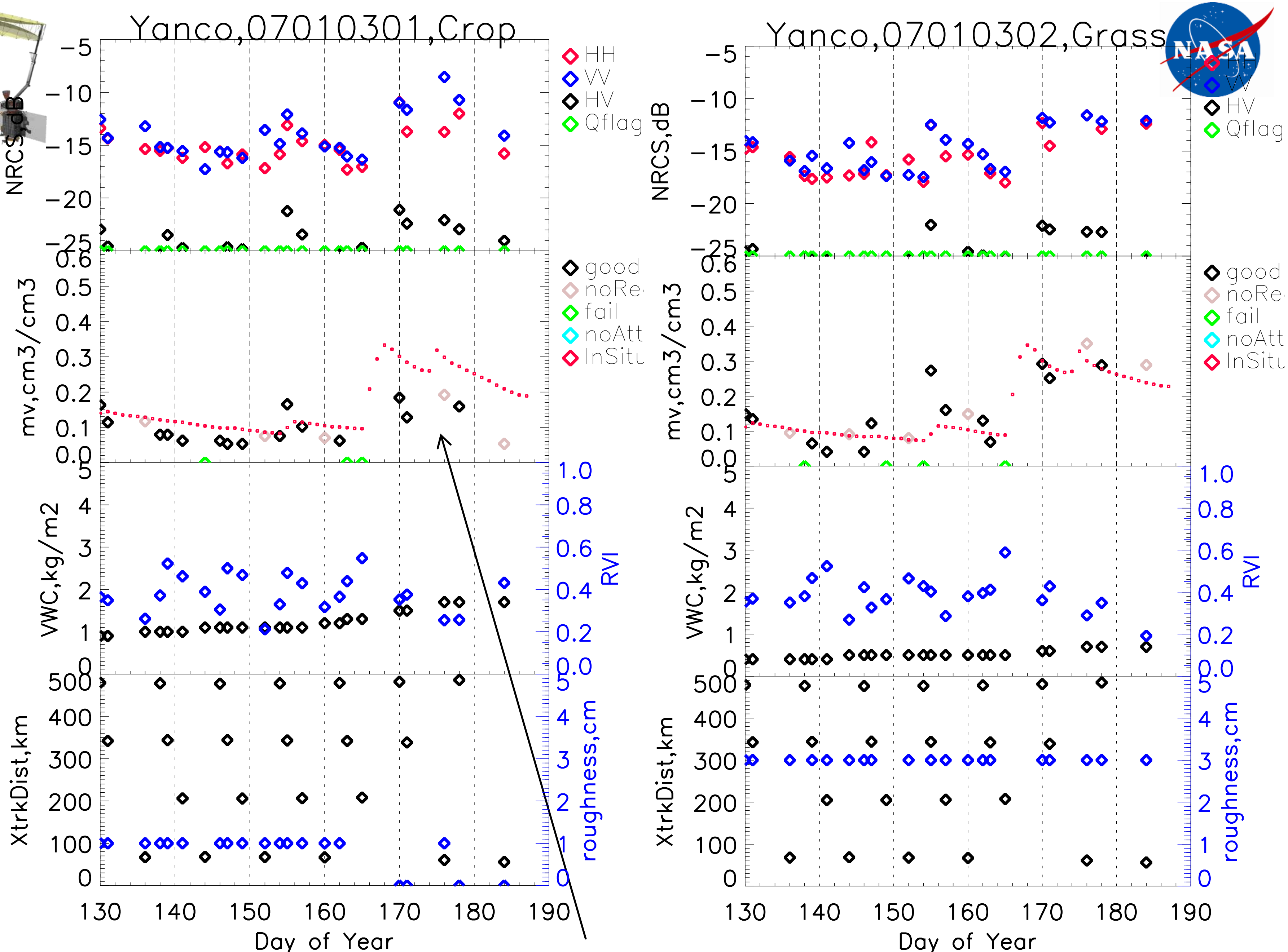


# L2SMA analysis: CalVal core sites

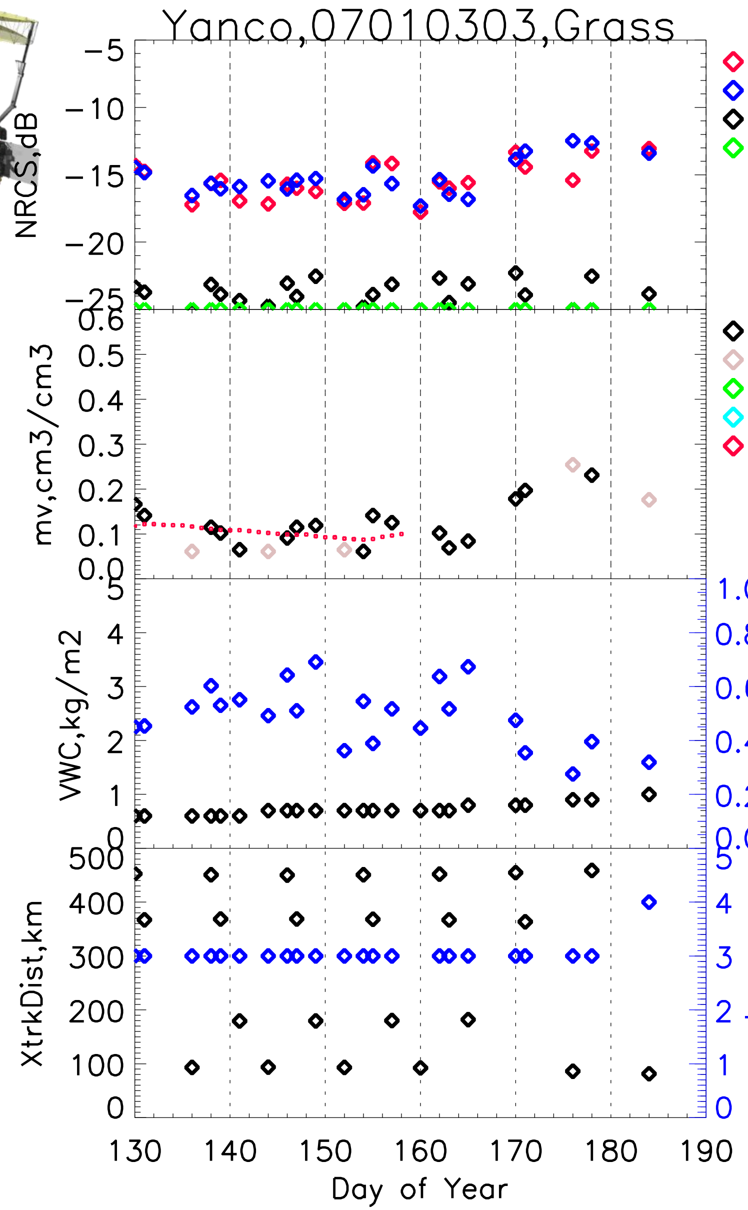
- Best chance for success or understanding of retrieval
  - Goal: solicit insights from CalVal coresite partners

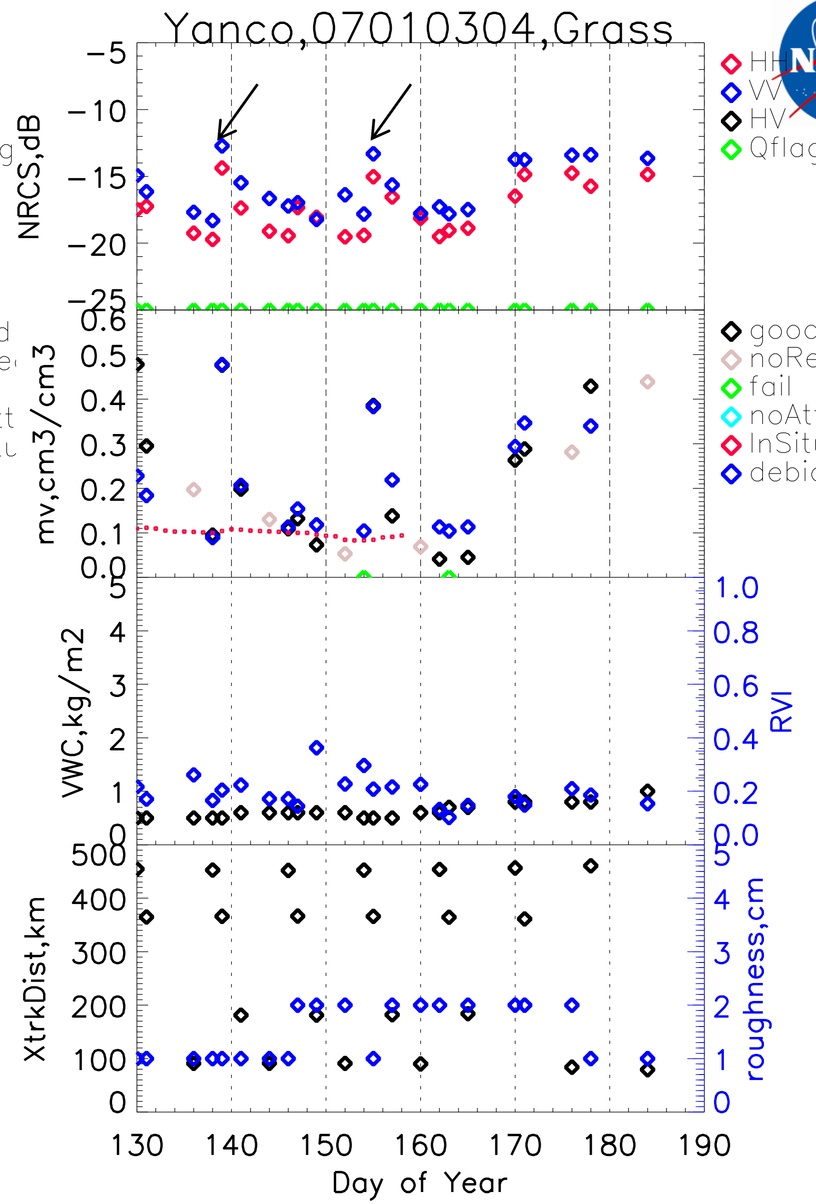
- The plots were made by smapm_ac_match_a1_150831.pro


HOAL,06010301,Crop
NRCS,dB
-5
-10
-15
-20
-25
HH
VV
HV
Qflag
mv,cm3/cm3
0.0
0.1
0.2
0.3
0.4
0.5
0.6
good
noRe
fail
noAtt
InSitu
VWC,kg/m2
0
1
2
3
4
5
RVI
0.0
0.2
0.4
0.6
0.8
1.0
XtrkDist,km
0
100
200
300
400
500
roughness,cm
0
1
2
3
4
5
130
140
150
160
170
180
190
Day of Year



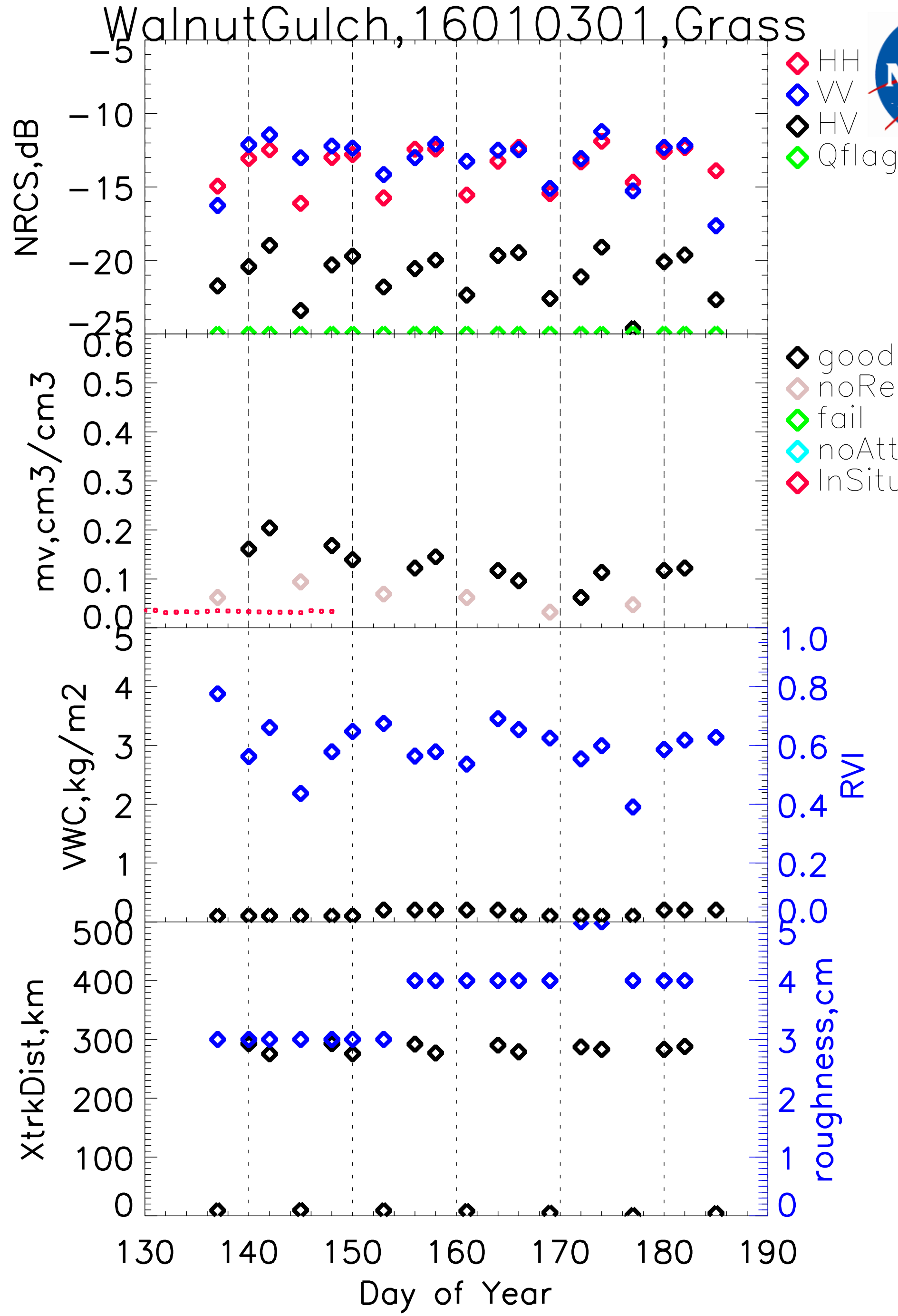

Copol s0 responds to Mv. Retrieval problem with rmsh. Fixed in Yanco2

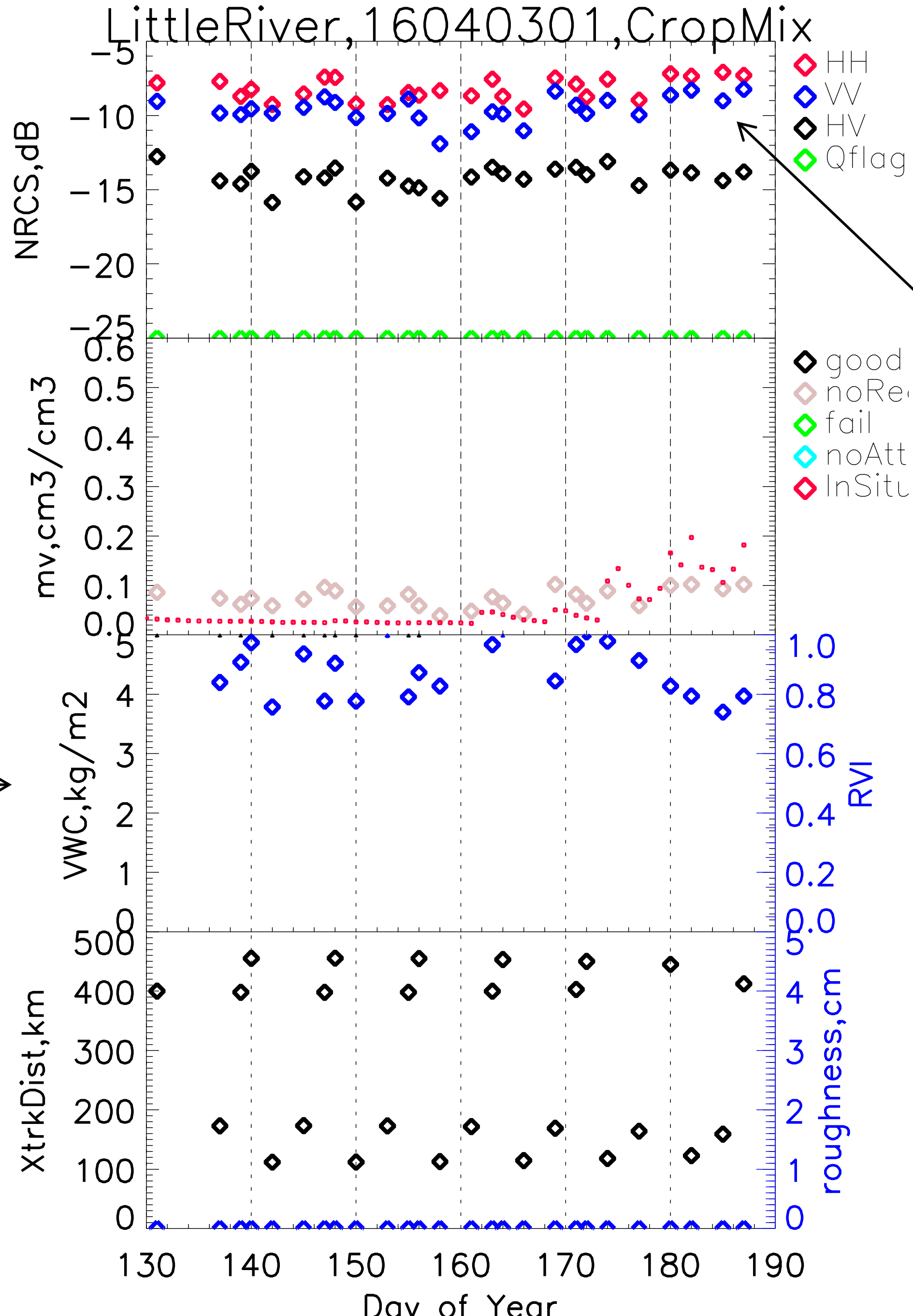



- Yanco4: compared with Yanco3, s0 variation is very large (while mvt is the same; RVI is lower) → large swings of retrieval. Azimuth effect not obvious.

MVR is too wet – topography?





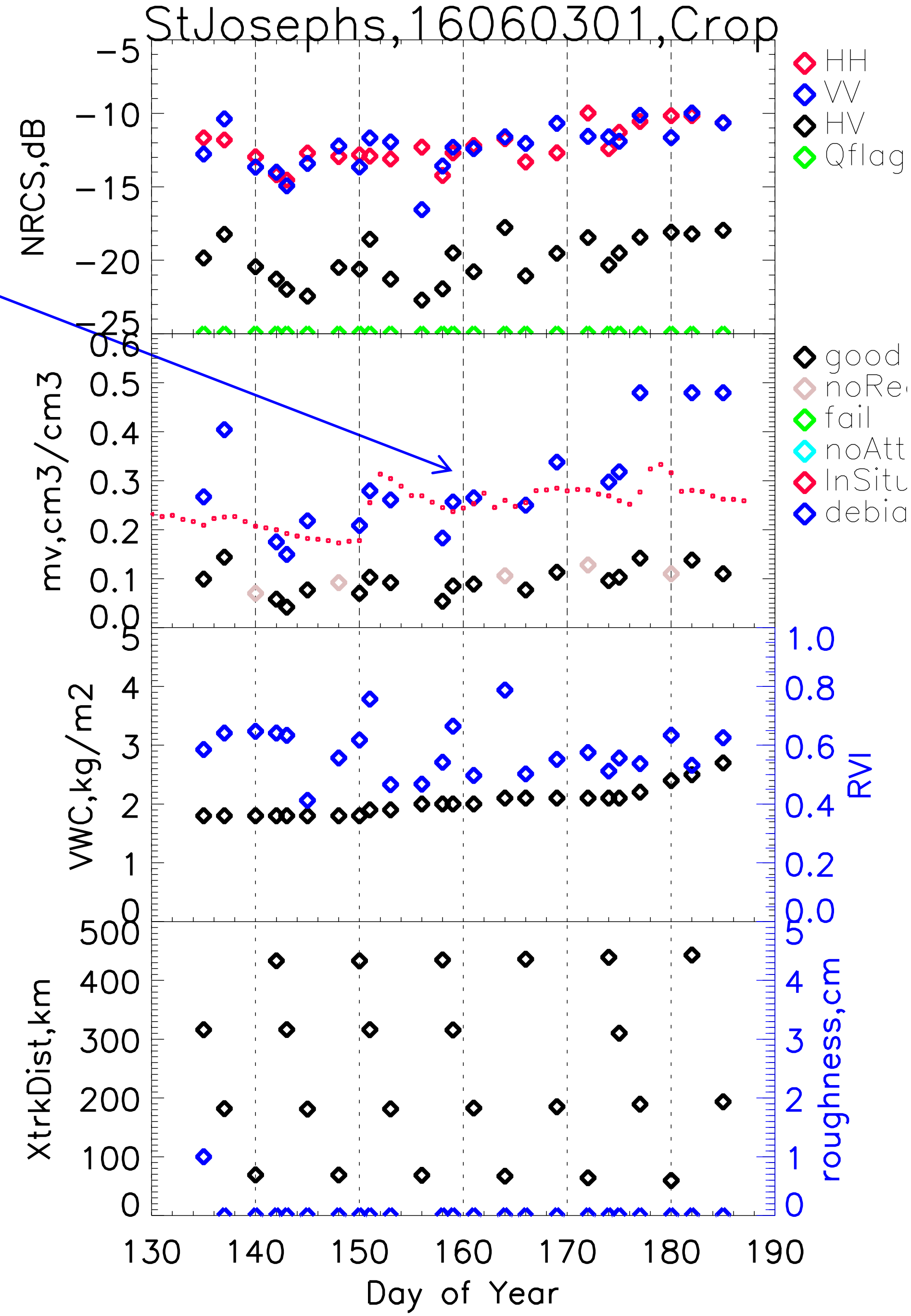

S0 is not responding to Mv

VWC > 5 kg/m2.

(Q) Is this correct?

(Q) What kind of crop type?

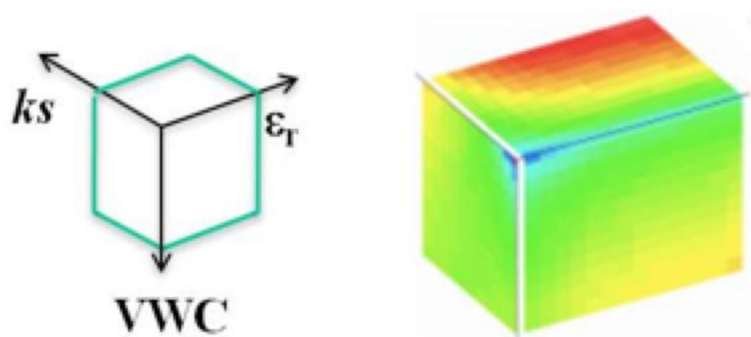
Retrieval after bias estimate



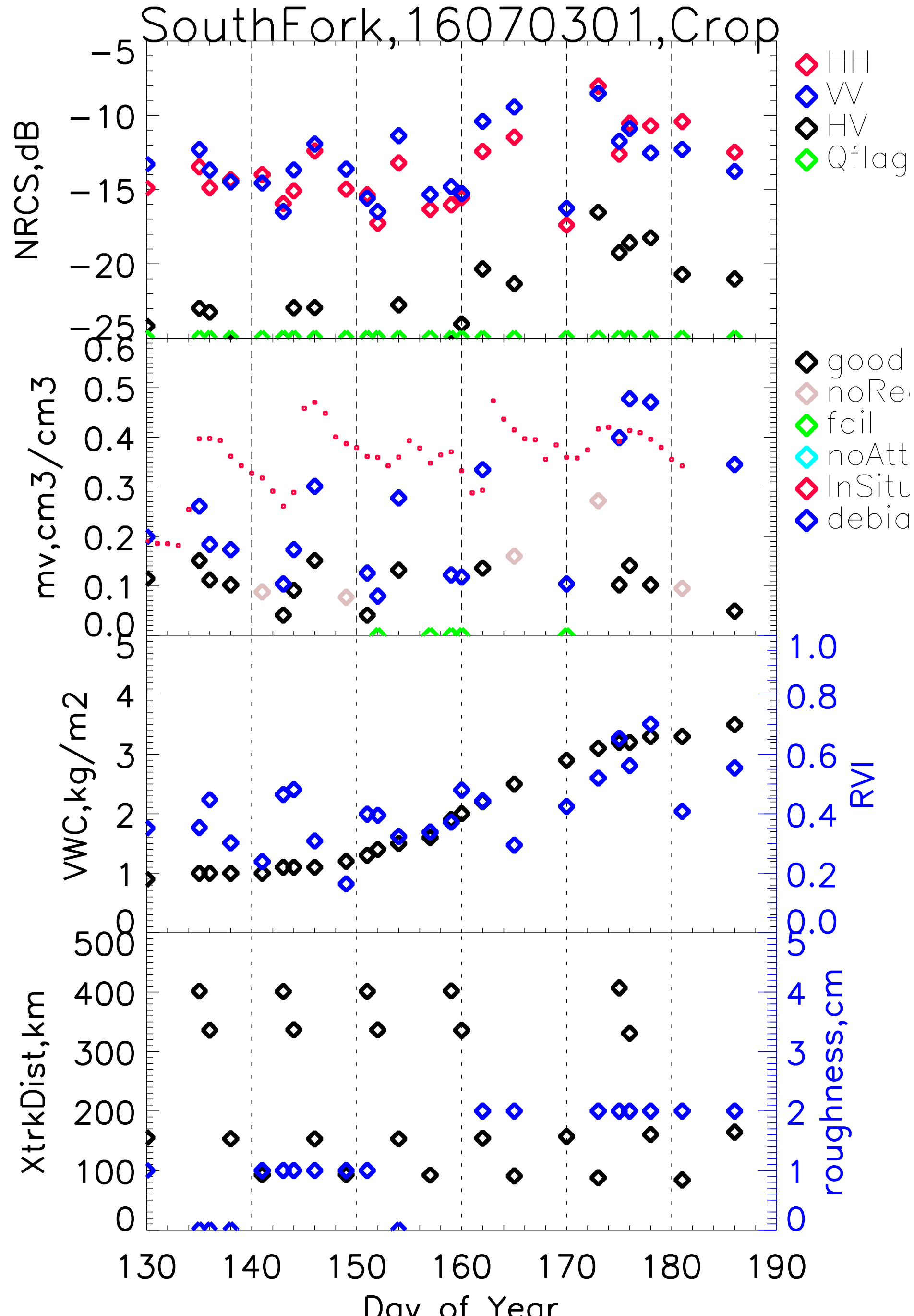
# Improvement of Retrieval

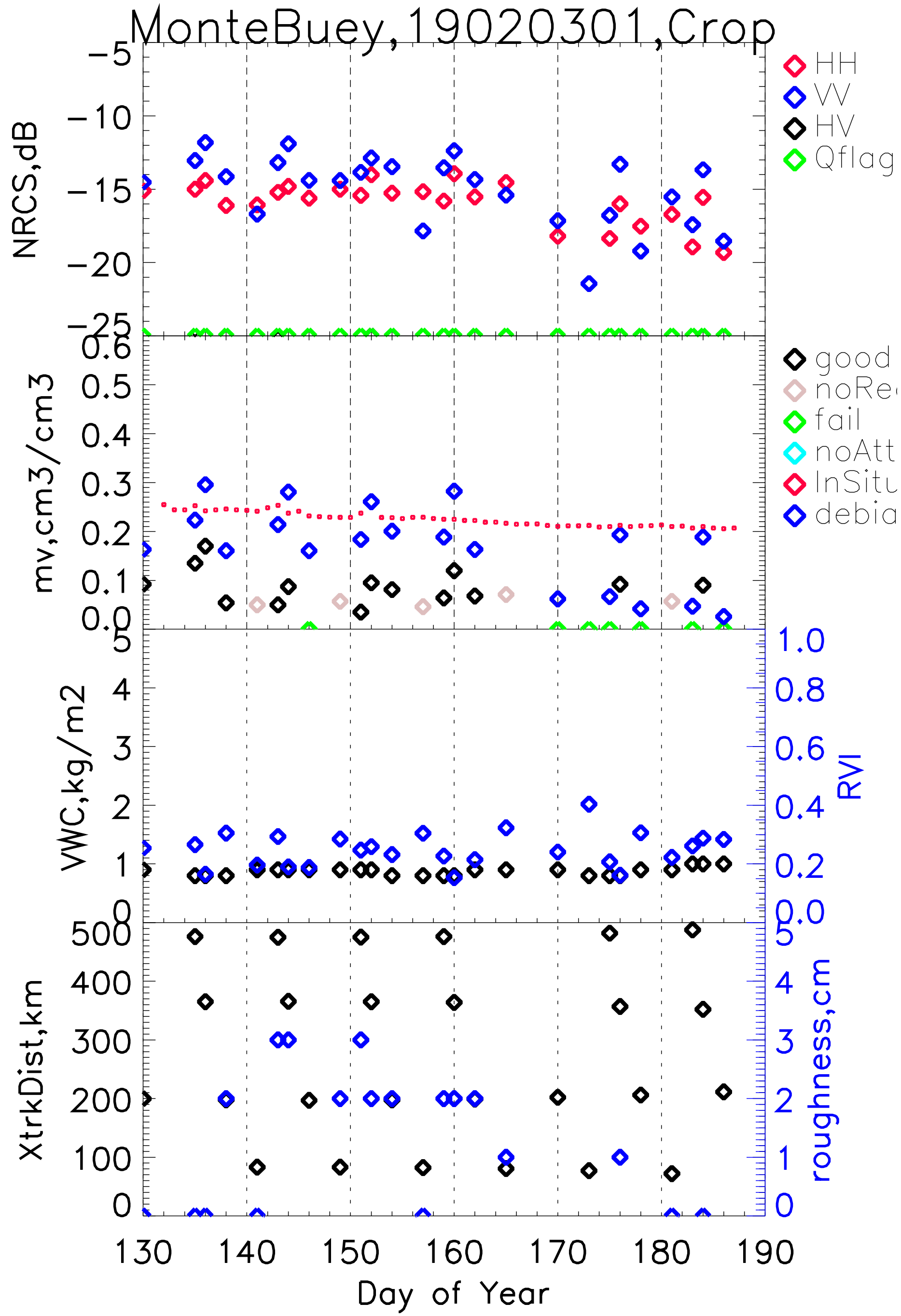
| Unknown | Input | Degrees Freedom |
|---|---|---|
| N (Mv)+1 (s) | 2N (HH, VV) | N< <2N (Konig et al. 15) |
| 7 | 14 | 10 |

Estimating bias? Adjusting VWC?



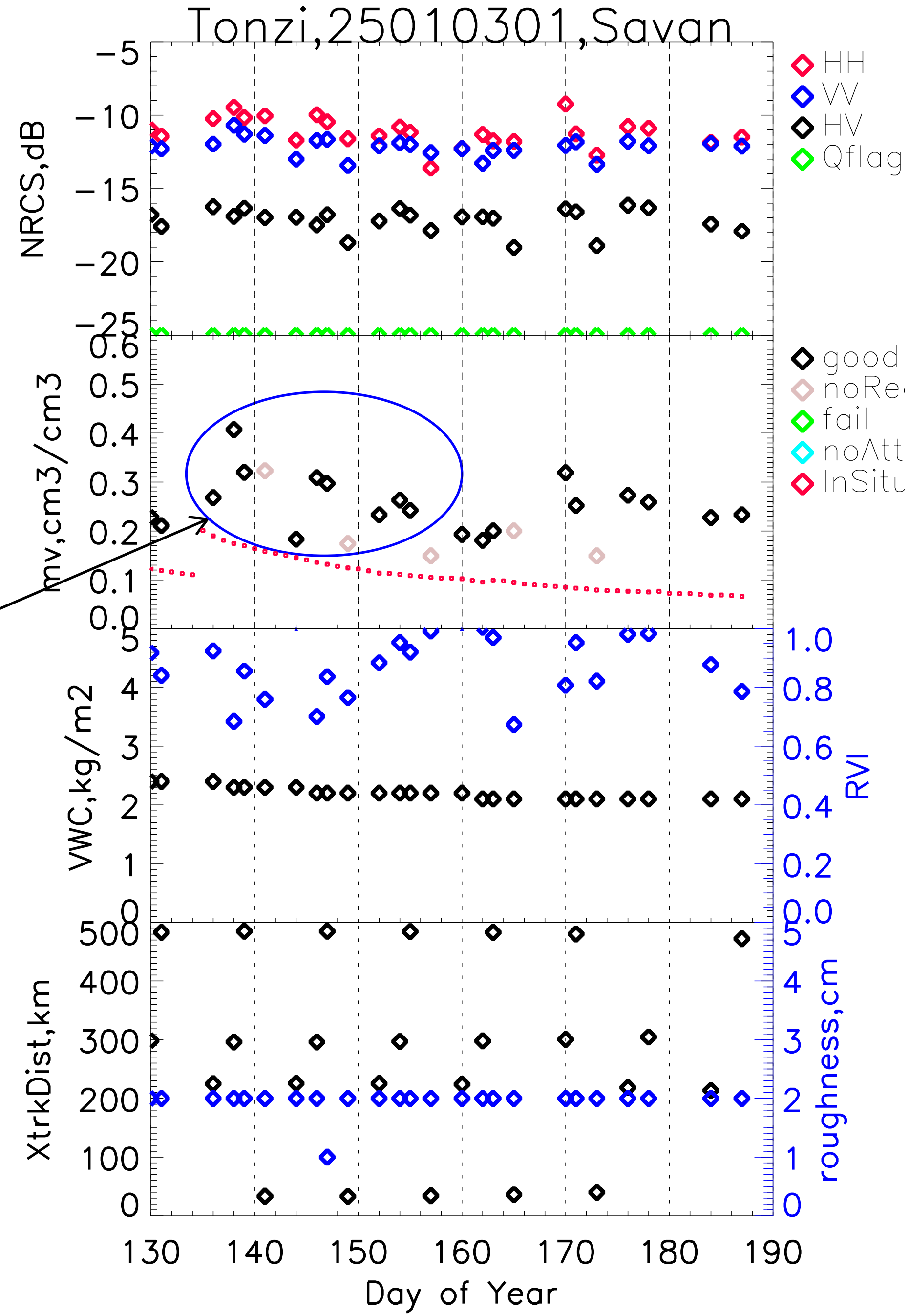
Bias is removed



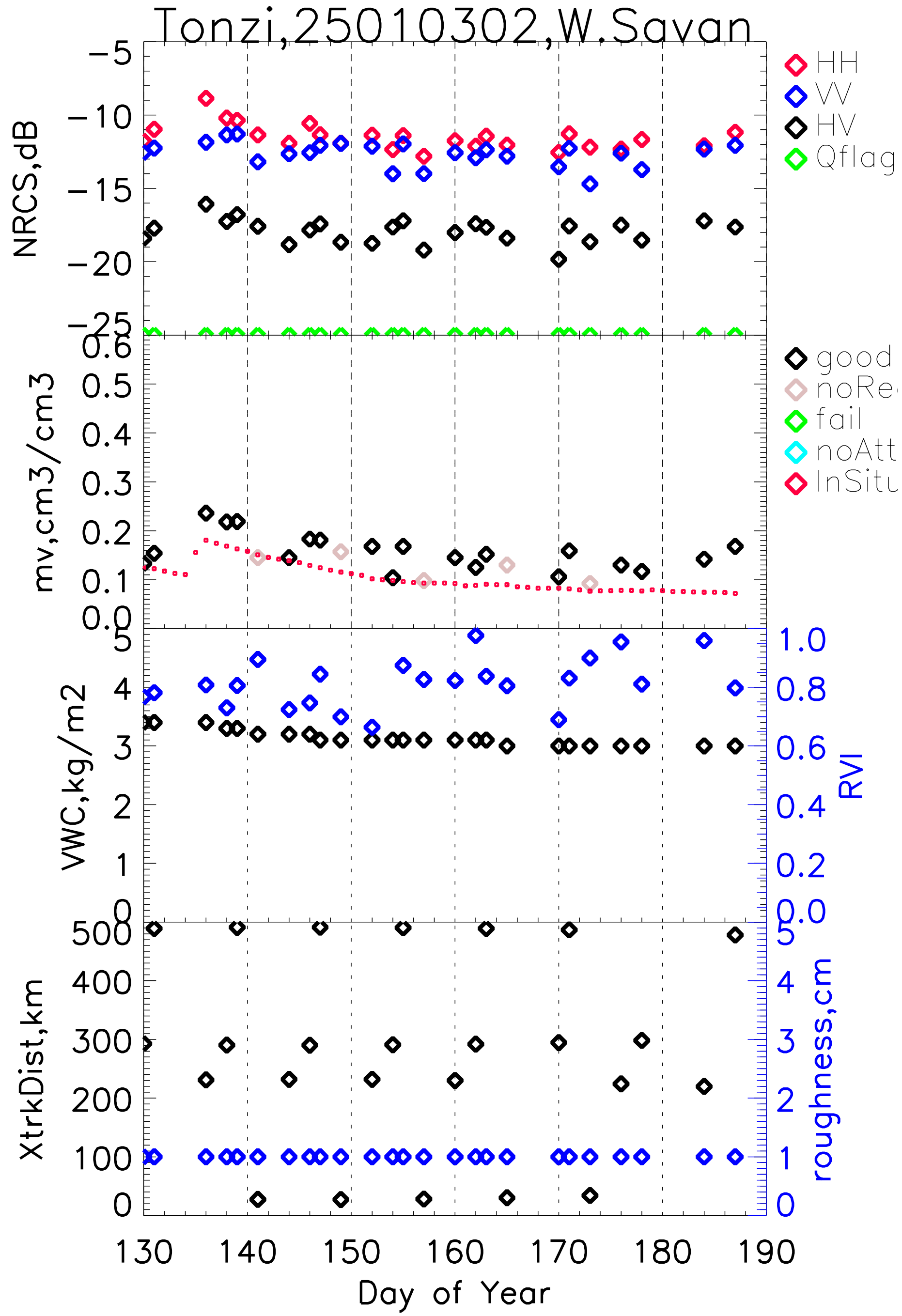



Bias is removed

VWC reduced based on in situ information from Marc Thibeault

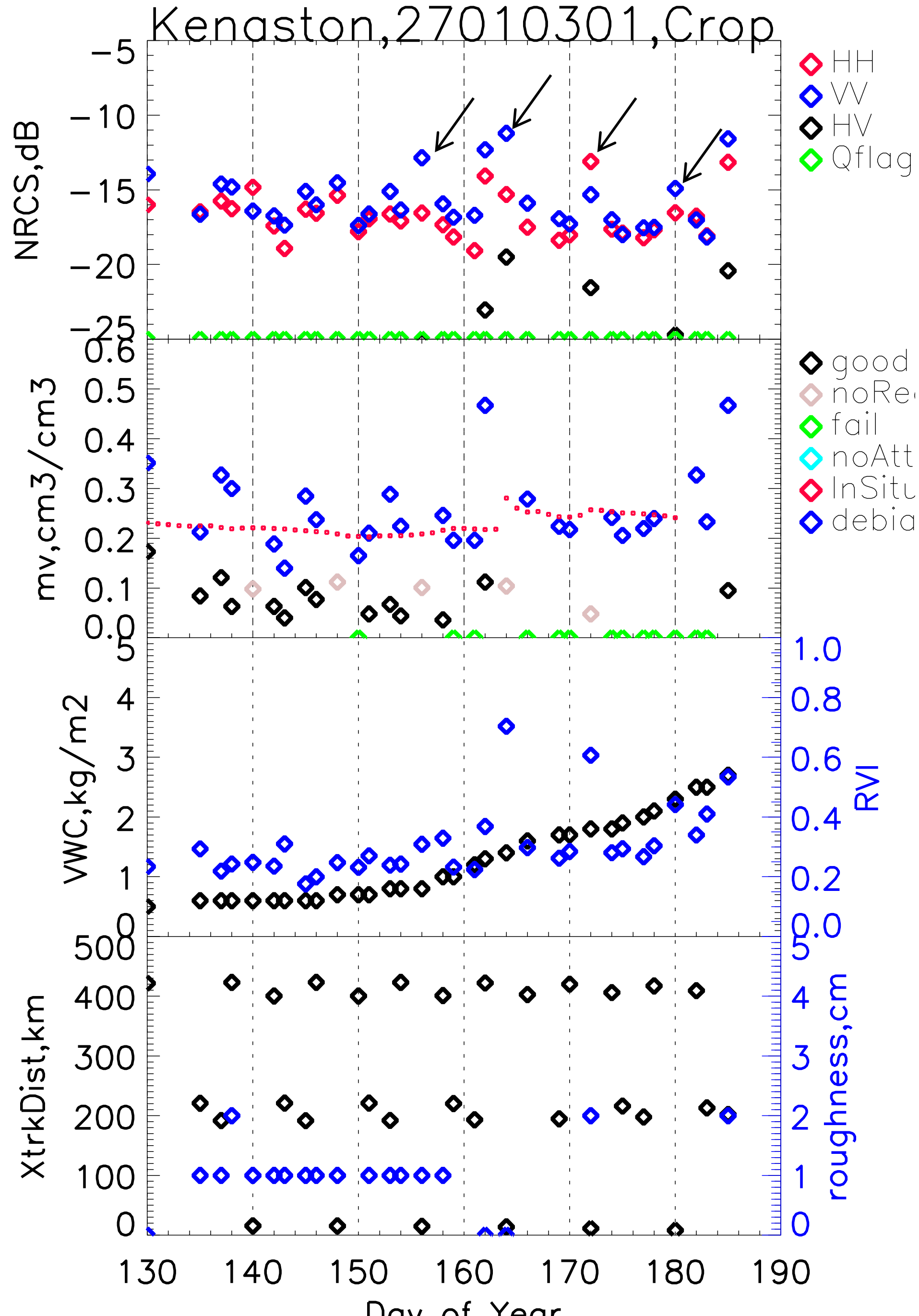



- Undulations are due to s0. Appear to be azimuth angle dependent – but not applicable later
- Topography can lead to azimuth effect and bias.

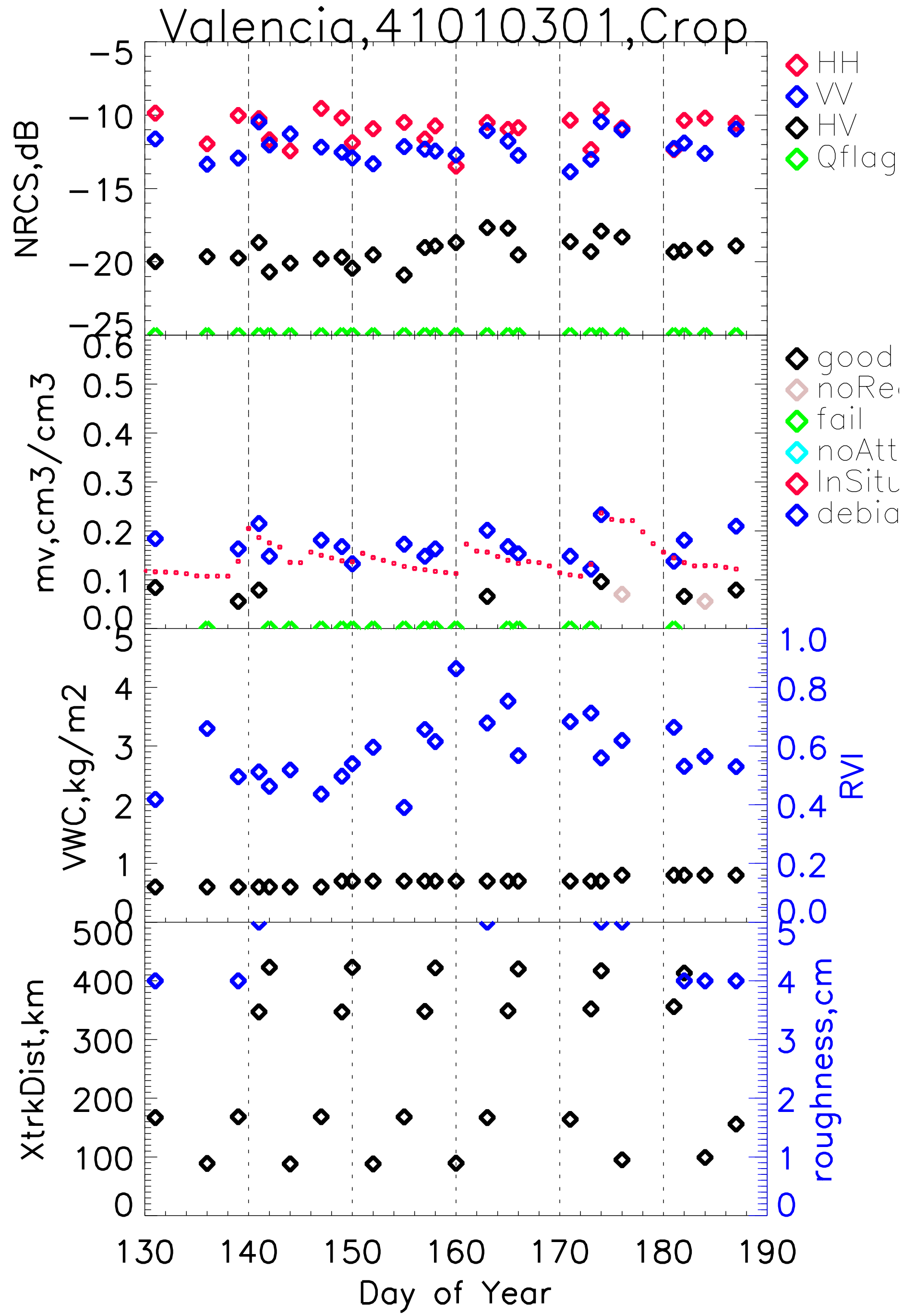


Tonzi,25010302,W.Savan
NRCS,dB
HH
VV
HV
Qflag
mv,cm3/cm3
good
noRe
fail
noAtt
InSitu
VWC,kg/m2
RVI
XtrkDist,km
roughness,cm
Day of Year

- Some spikes in sigma0 are due to nadir pixels – not all.




Bias is removed

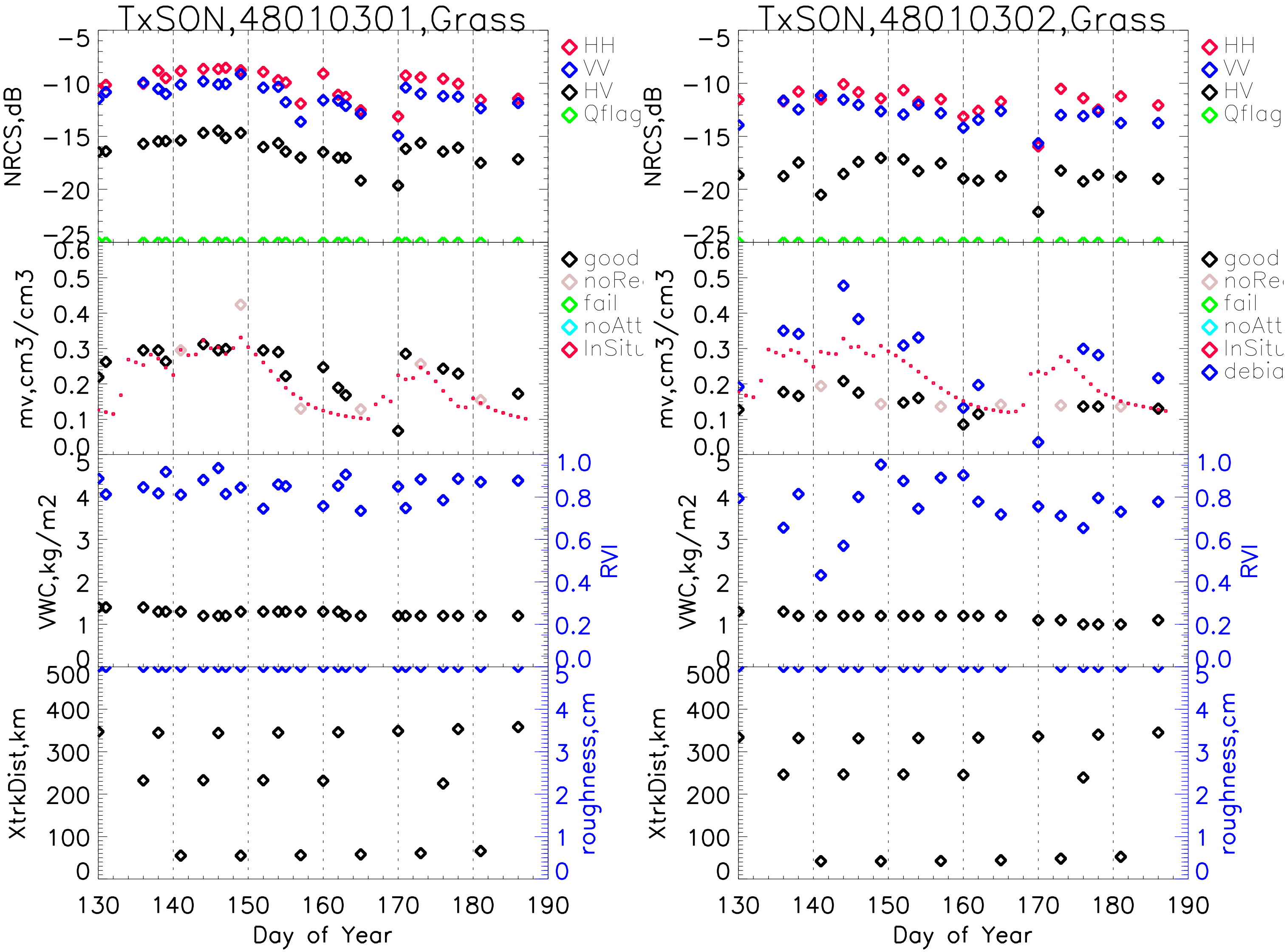



Bias is removed

MeanE=0.031

ubRMSE=0.027

(cm3/cm3)




Bias is removed

- site 301 on the day ~160 and day 170: poor retrievals follow sigma0.
- site 302 has smaller sigma0 than site 301 but input VWC is the same → drier retrieval. RVI is smaller. Need to adjust VWC

# Statistics (T11830-199)

2015/05/08 - 2015/07/09

## Performance Metrics by Land Cover Class (IGBP)

| Land Cover | Ref Pixel | ubRMSE | Bias | RMSE | R |
|---|---|---|---|---|---|
| **Croplands** | St Josephs (1606-03-01) | 0.033 | -0.148 | 0.151 | 0.506 |
| | Kenaston (2701-03-01) | 0.000 | -0.102 | 0.102 | NaN |
| | Kenaston (2701-03-02) | NaN | NaN | NaN | NaN |
| | Monte Buey (1902-03-01) | NaN | NaN | NaN | NaN |
| | Valencia (4101-03-01) | 0.035 | -0.083 | 0.090 | 0.508 |
| | Yanco (0701-03-01) | 0.055 | -0.041 | 0.069 | 0.687 |
| | **MEAN:** | **0.031** | **-0.094** | **0.103** | **0.567** |
| **Grasslands** | Walnut Gulch (1601-03-01) | NaN | NaN | NaN | NaN |
| | TxSON (4801-03-01) | 0.063 | 0.048 | 0.079 | 0.541 |
| | TxSON (4801-03-02) | 0.041 | -0.075 | 0.086 | 0.880 |
| | Yanco (0701-03-02) | 0.051 | 0.036 | 0.063 | 0.800 |
| | Yanco (0701-03-03) | 0.020 | 0.021 | 0.029 | 0.367 |
| | Yanco (0701-03-04) | 0.035 | 0.338 | 0.339 | 1.000 |
| | **MEAN:** | **0.042** | **0.073** | **0.119** | **0.718** |
| **Shrub open** | Walnut Gulch (1601-03-02) | NaN | NaN | NaN | NaN |
| | **MEAN:** | **NaN** | **NaN** | **NaN** | **NaN** |

Stats do not include the improvements by debiasing.

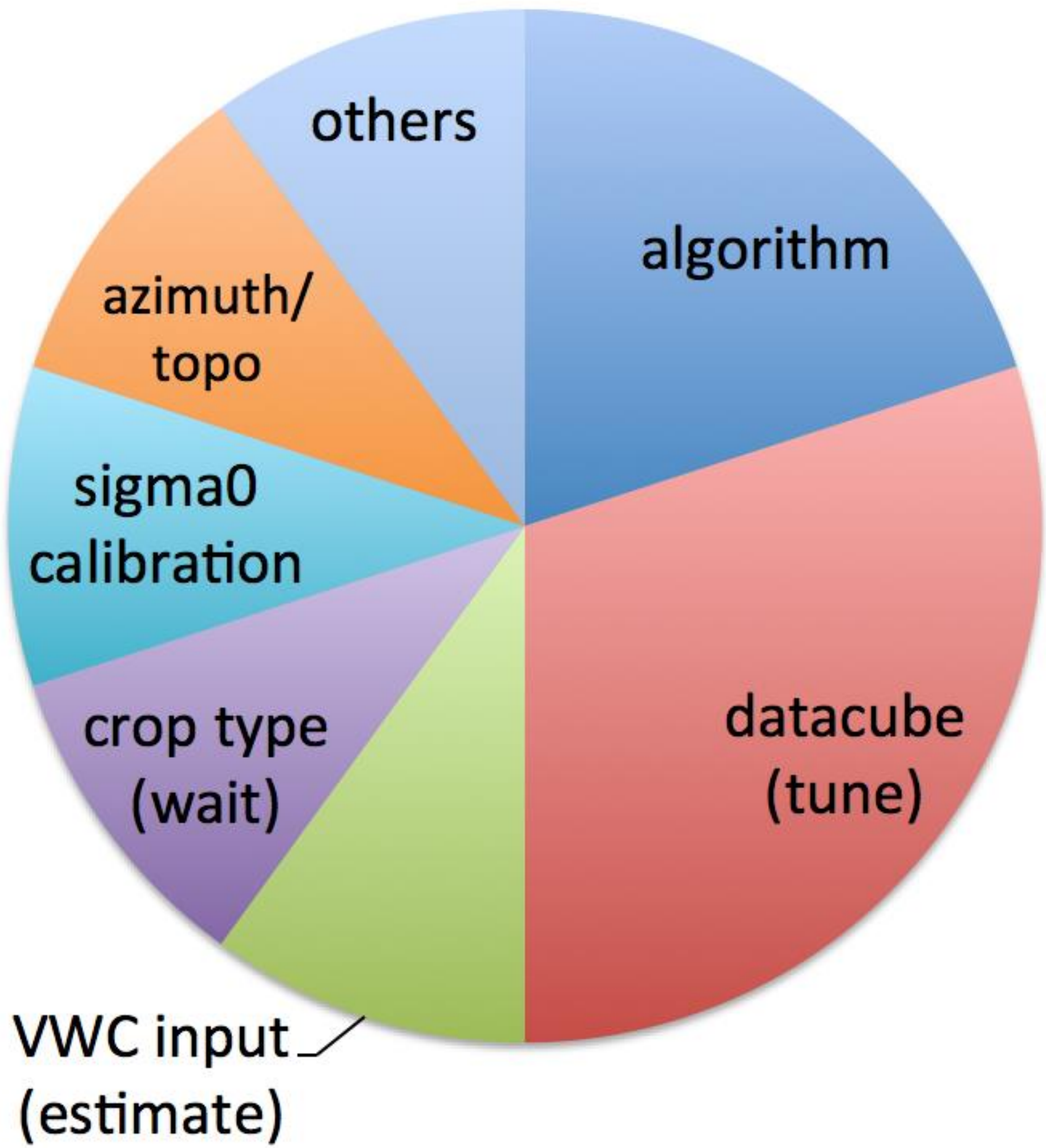
# Summary

- Core site validation
  - ubRMSE ranging from 0.03 to 0.04 cm3/cm3
  - Reduction of the retrieval bias improves the results.

- Sites not presented
  - Zapotes (Tabasco), EURAC: past time-series s0 is not generated due to static water flag and mountain flag (will overide to enable retrieval).
  - Finnish sites: challenging (organic soil, wetland)

- Information needed to improve cropland retrieval
  - Crop type
  - VWC
  - Change in surface roughness: tillage?

# Sources of Errors



# Plans and milestones

- L2 beta release in Sept. 2015 (L2SMP)
- Validated product release (May 2016)

| Major task (in the order of importance) | Milestone |
|---|---|
| A. L1C calibration (xtrack anomaly, RFI) | done |
| B. Forward model evaluation (wrt SMAP s0) | end Sept |
| C. Understand/Improve core-site validation | end Aug (✓) |
| D. Understand/Improve failures/no-recommend | end Aug (✓) |
| E. Iterative (or VWC) retrieval implementation | end Sept |
| F. Analyze product intercomparison | mid Sept |
| H. Topography & heterogeneity | May 2016 |
| K. Flags: rationalize | May 2016 |
| L. Ascending track retrieval | Open |
| M. Error bars | May 2016 |