National Aeronautics and Space Administration

ECOSTRESS

Simulated Data

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ECOSTRESS Science Team meeting, UC Davis, CA, 15-17 May 2017

Why?

1. SDS Timing of Algorithms
2. PCS End-to-End testing, i.e. L0-L4
3. Early adopters, e.g. EARTH, UC Davis, DEVELOP

VIIRS Quick Facts

- VIIRS: Visible Infrared Imaging Radiometer Suite

  "MODIS follow-on"

- 5 High resolution Imagery channels (I-bands) 375m

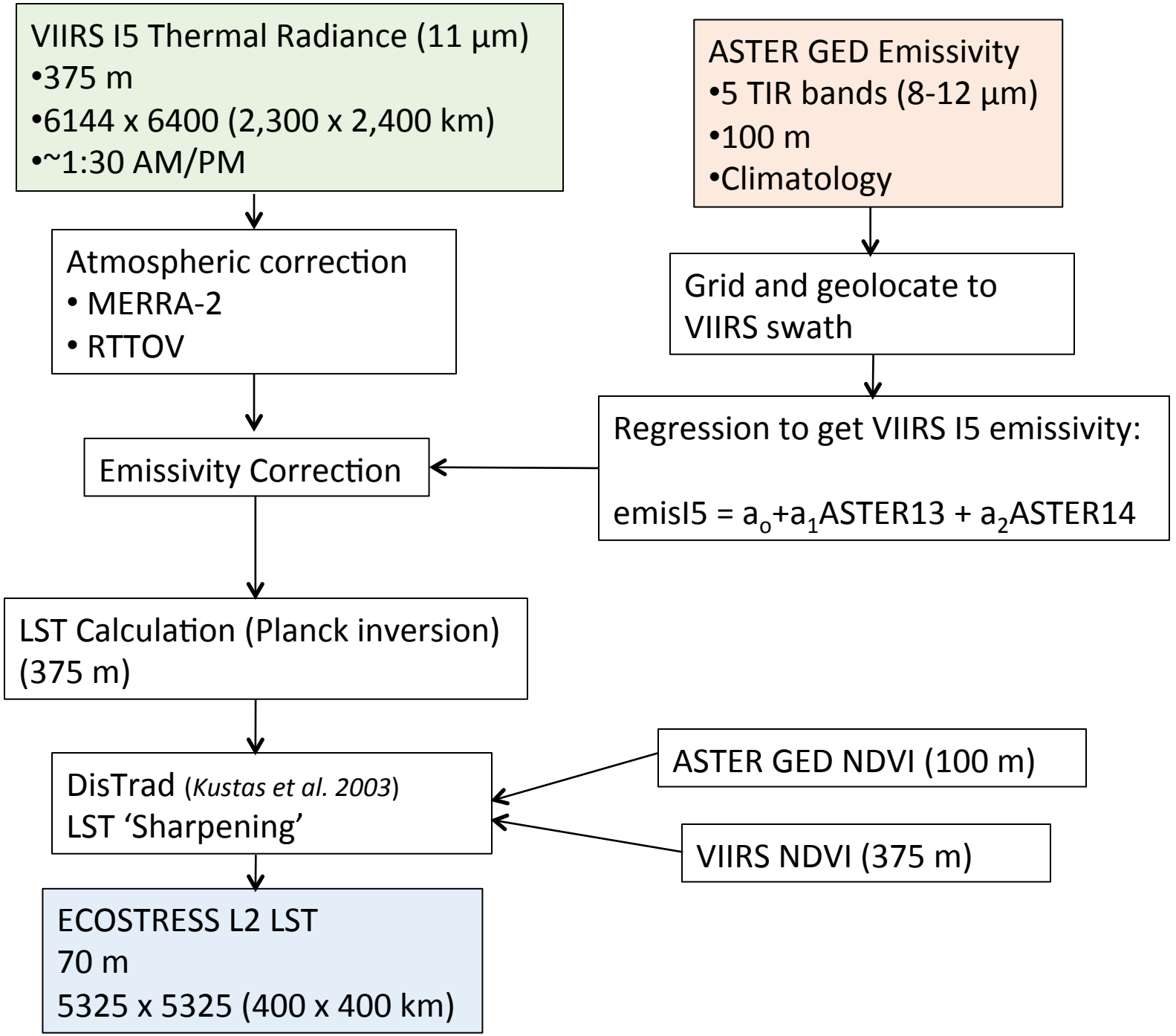
- 16 Moderate resolution channels (M-bands) 750m

- Day/Night Band (DNB)

VIIRS first launched onboard Suomi-NPP on 28 October 2011

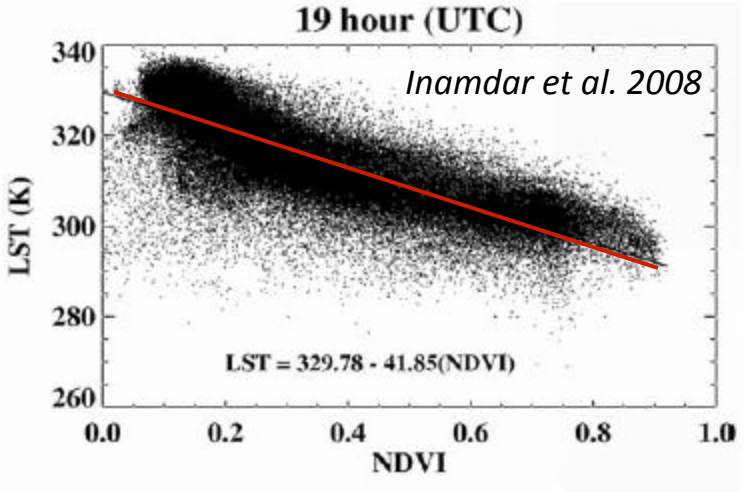
Suomi-NPP is in the same orbital plane as the A-Train (CloudSat, CALIPSO, Terra MODIS), but at higher altitude: sun synchronous at ~824 km with ~13:30 LT equator crossing.

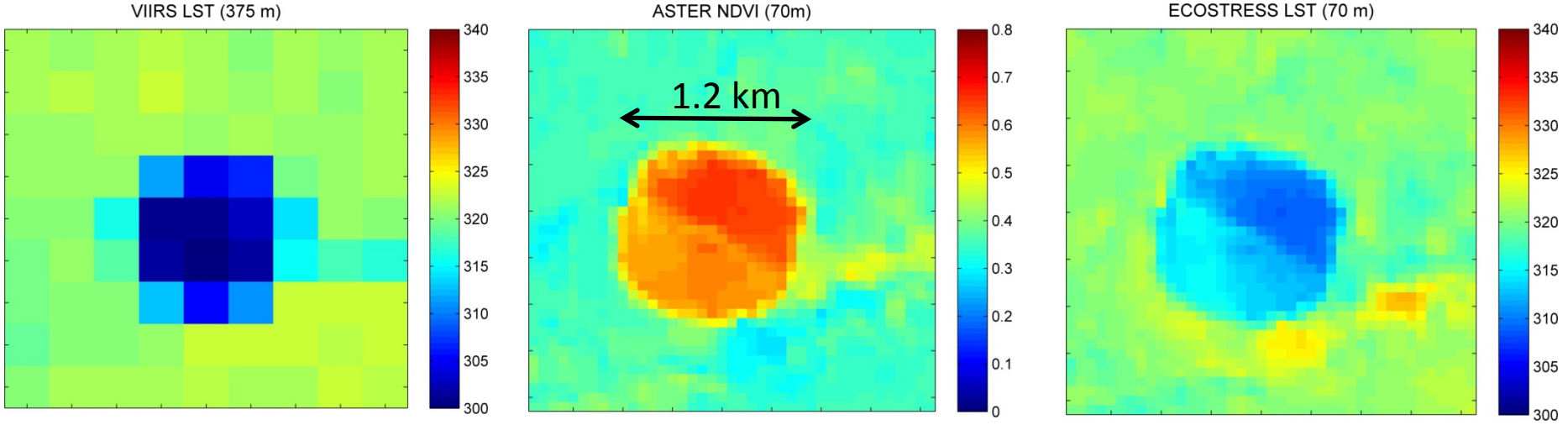
- Purpose: collect measurements of clouds, aerosols, ocean color, surface temperature, fires, and albedo

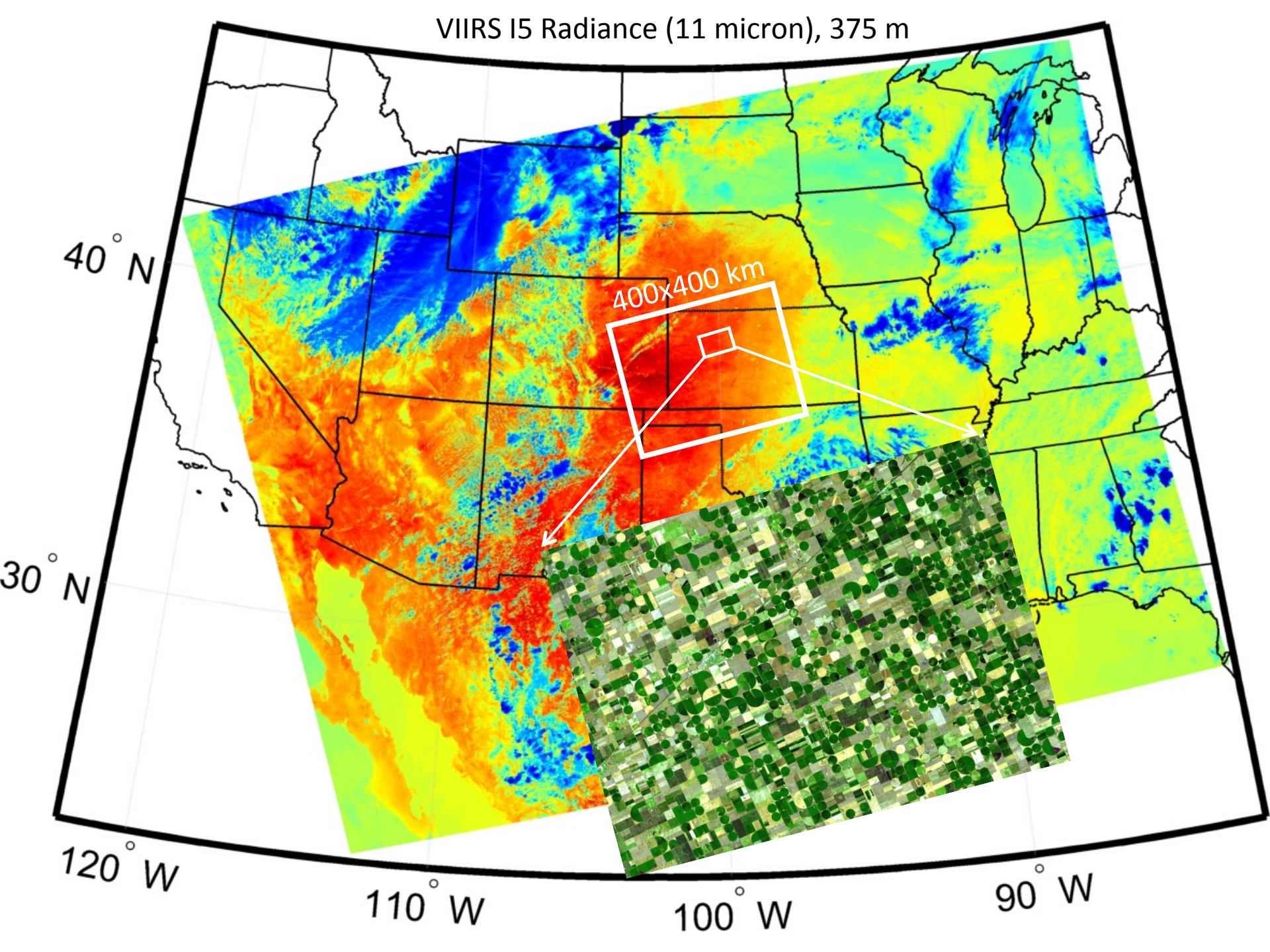

VIIRS I5 Thermal Radiance (11 µm)
•375 m
•6144 x 6400 (2,300 x 2,400 km)
•~1:30 AM/PM
ASTER GED Emissivity
•5 TIR bands (8-12 µm)
•100 m
•Climatology
Atmospheric correction
• MERRA-2
• RTTOV
Grid and geolocate to VIIRS swath
Regression to get VIIRS I5 emissivity:
emisI5 = a0+a1ASTER13 + a2ASTER14
Emissivity Correction
LST Calculation (Planck inversion) (375 m)
DisTrad (Kustas et al. 2003)
LST 'Sharpening'
ASTER GED NDVI (100 m)
VIIRS NDVI (375 m)
ECOSTRESS L2 LST
70 m
5325 x 5325 (400 x 400 km)

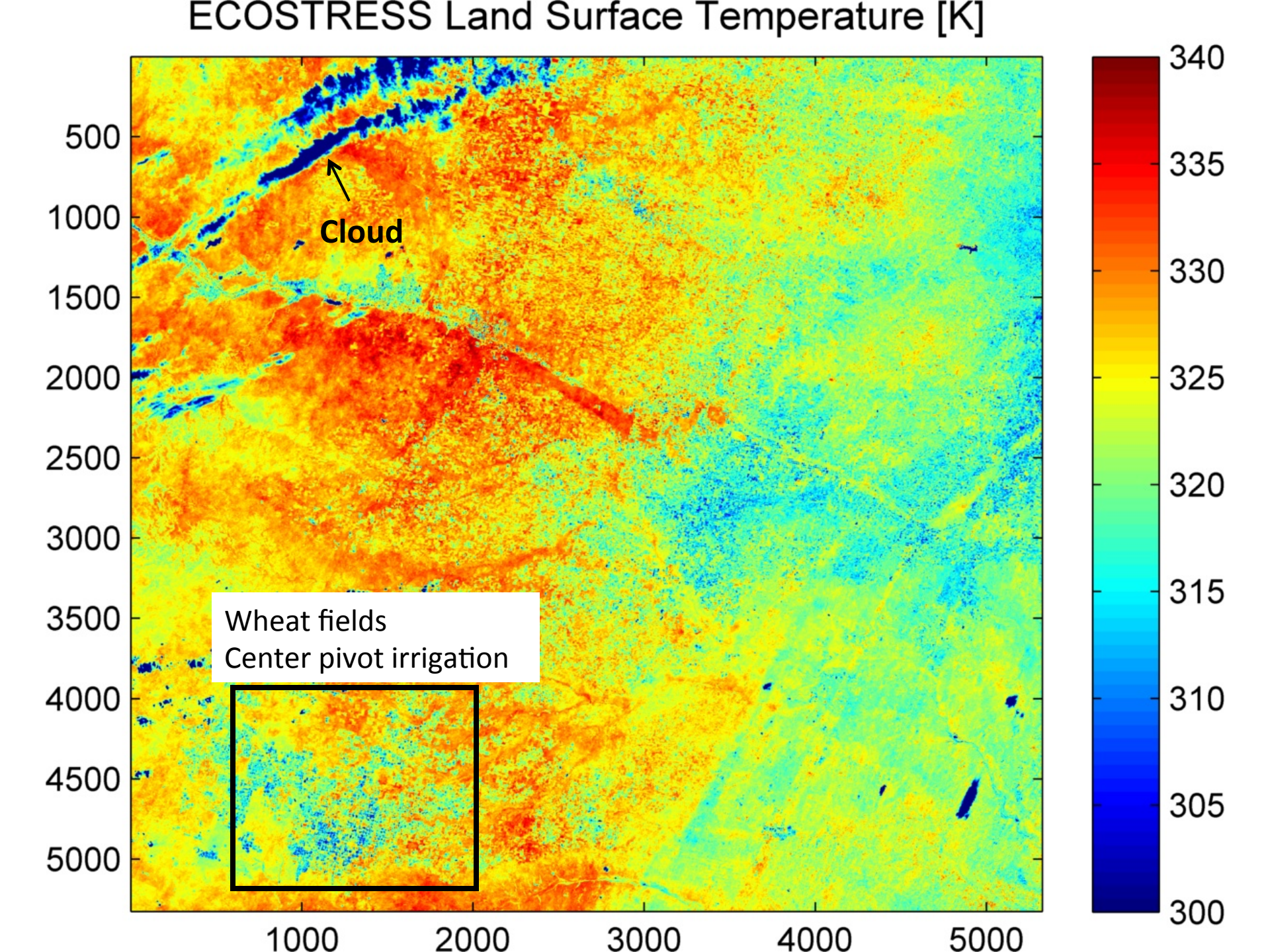
LST Disaggregation Approach (375 m ->70 m)

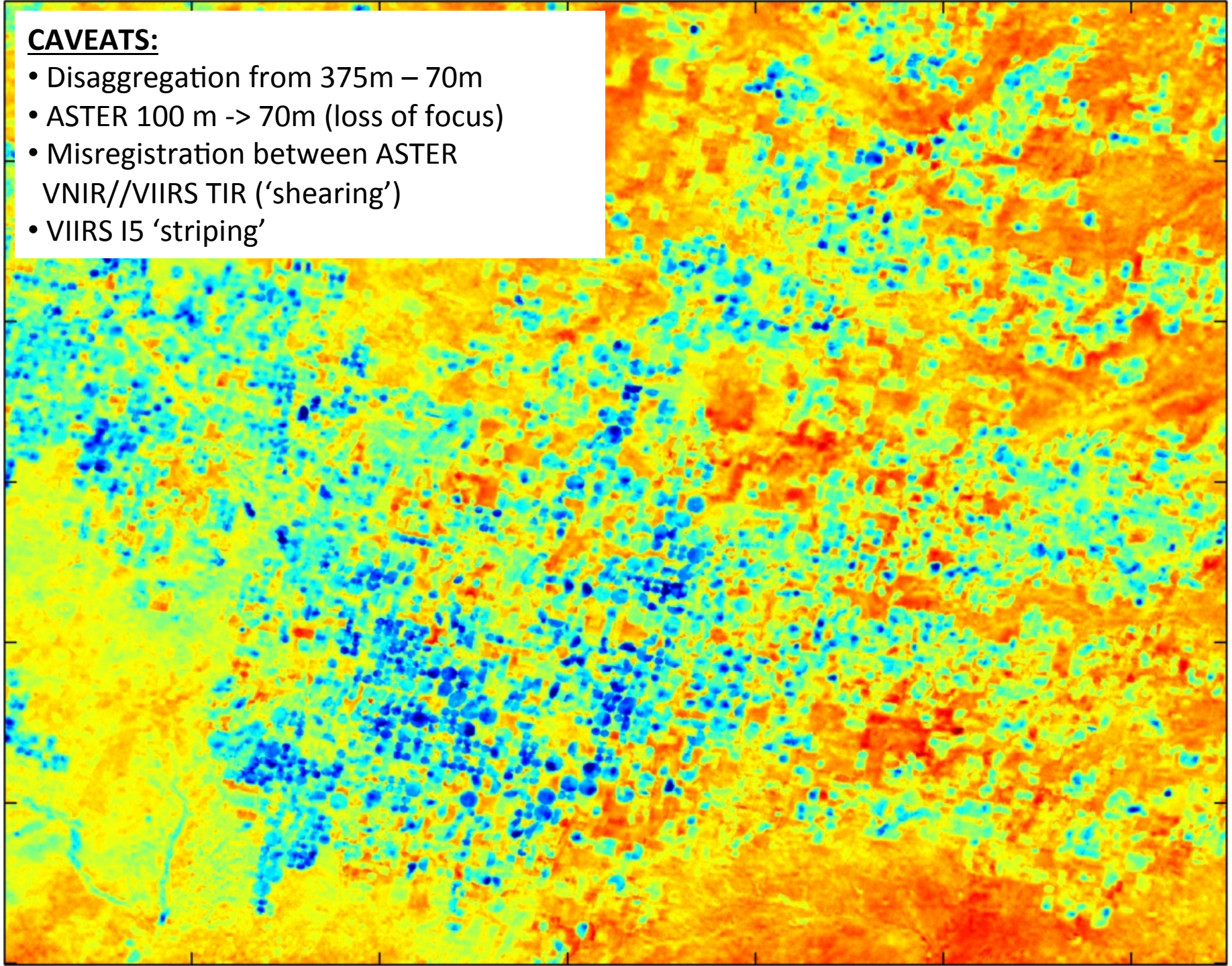
- Disaggregation procedure for radiometric surface temperature (DisTrad), *Kustas et al. 2003*
- Based on assumed relationship between vegetation 'greeness' and temperature

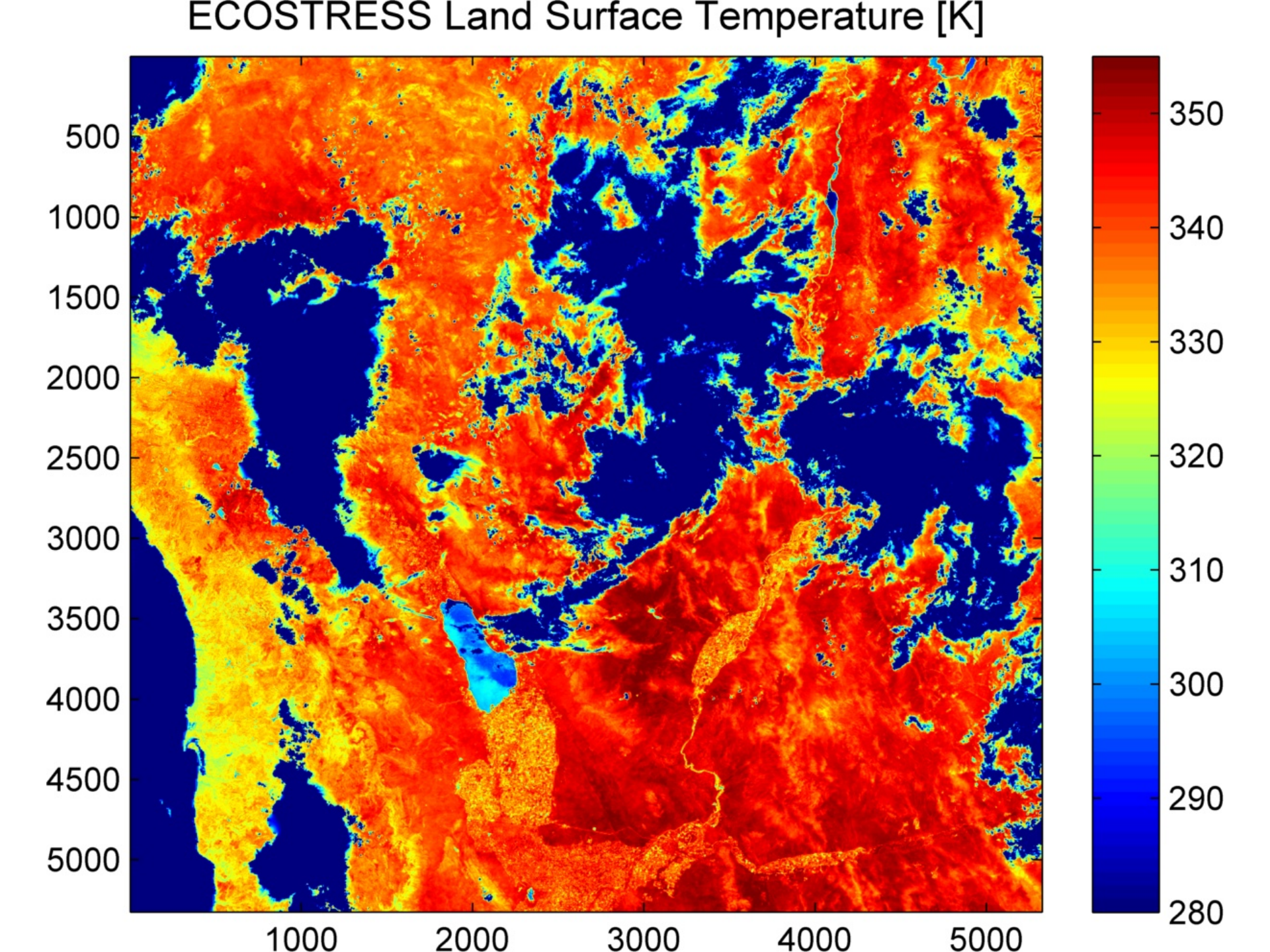




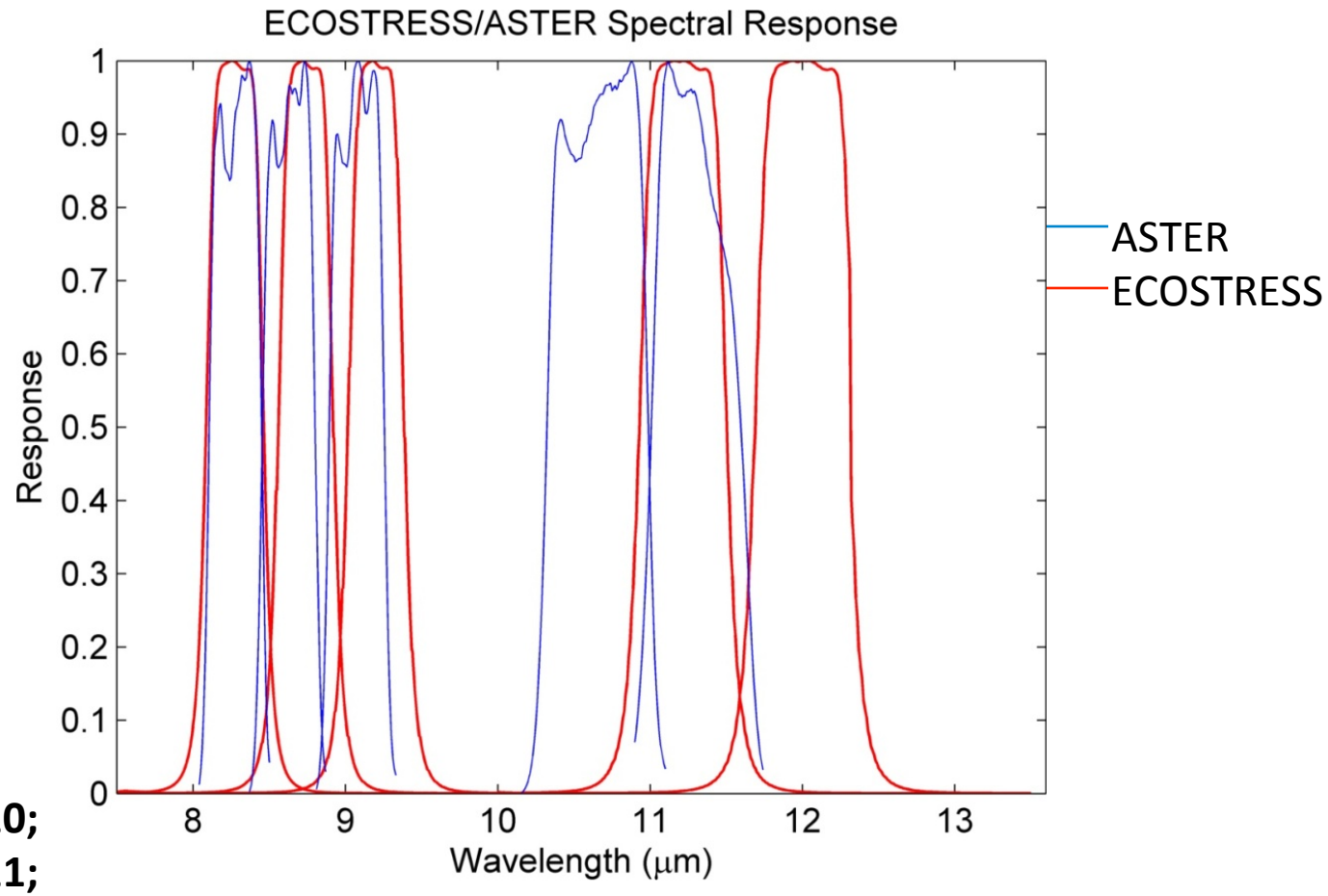

VIIRS I5 Radiance (11 micron), 375 m
400x400 km
40 ° N
30 ° N
120 ° W
110 ° W
100 ° W
90 ° W


ECOSTRESS Land Surface Temperature [K]
Cloud
Wheat fields
Center pivot irrigation
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
1000
2000
3000
4000
5000
340
335
330
325
320
315
310
305
300


CAVEATS:
• Disaggregation from 375m – 70m
• ASTER 100 m -> 70m (loss of focus)
• Misregistration between ASTER VNIR//VIIRS TIR ('shearing')
• VIIRS I5 'striping'

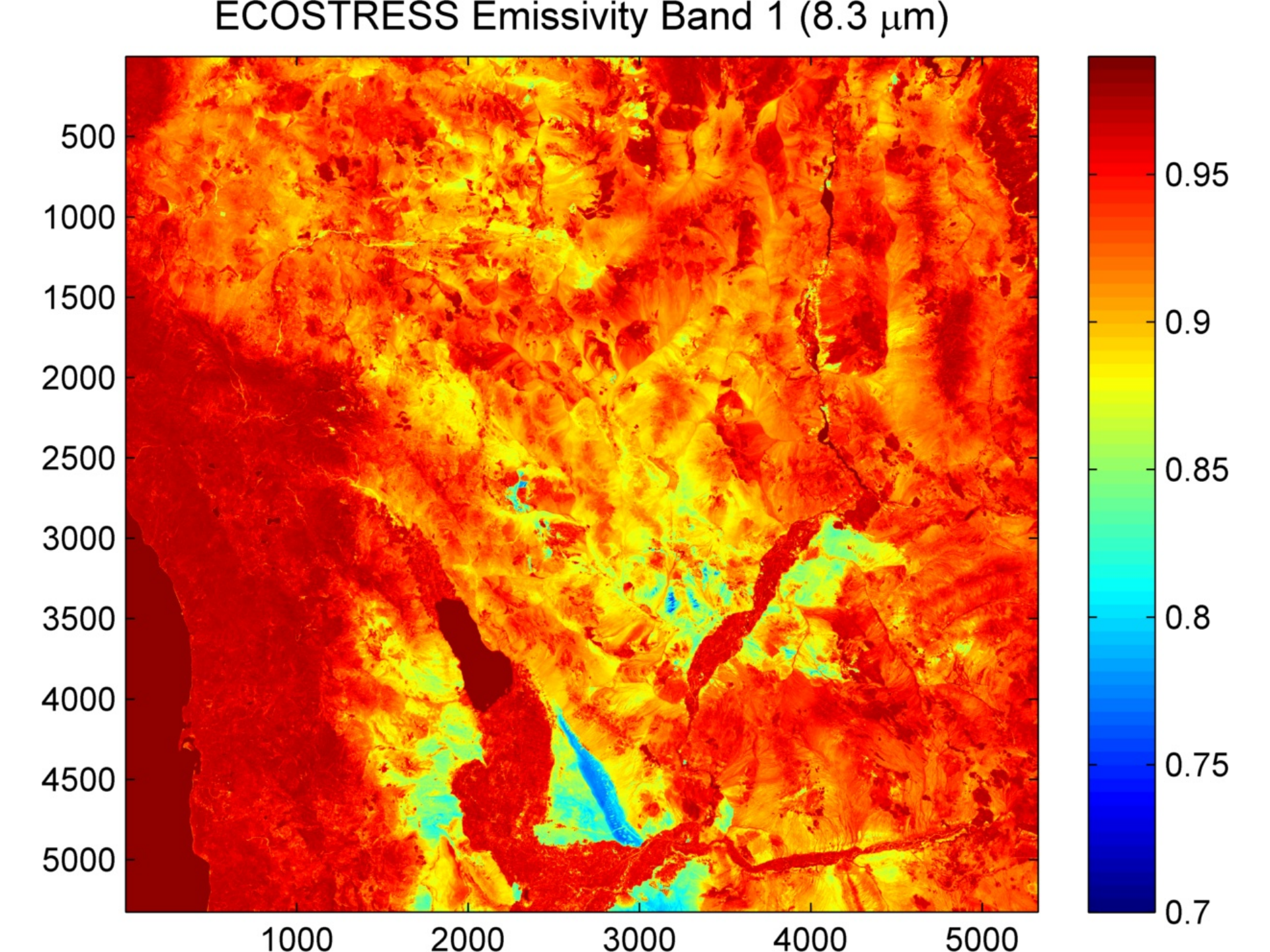

ECOSTRESS Land Surface Temperature [K]
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
1000
2000
3000
4000
5000
350
340
330
320
310
300
290
280

ECOSTRESS Emissivity Simulation



eco1temp = 0.9995.*e10;
eco2temp = 0.9922.*e11;
eco3temp = 0.9971.*e12;
eco4temp = 0.9995.*e14;
eco5temp = 1.01.*e14;

eco_bbcalc = 0.014*e10_mean + 0.145*e11_mean + 0.241*e12_mean + 0.467*e13_mean + 0.004*e14_mean + 0.128;


ECOSTRESS Emissivity Band 1 (8.3 μm)
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
1000
2000
3000
4000
5000
0.95
0.9
0.85
0.8
0.75
0.7

L2 Product: ECOSTRESS_L2_<ORBIT>_<SCENE>_<SCENETIME>_<BUILD>_<VERSION>.h5

L2 Simulated Example:
ECOSTRESS_L2_Kansas_201406171945_0000_V0-1.h5 (~ 2pm local)
(eco-scf @ /project/ancillary/simulated_data/)

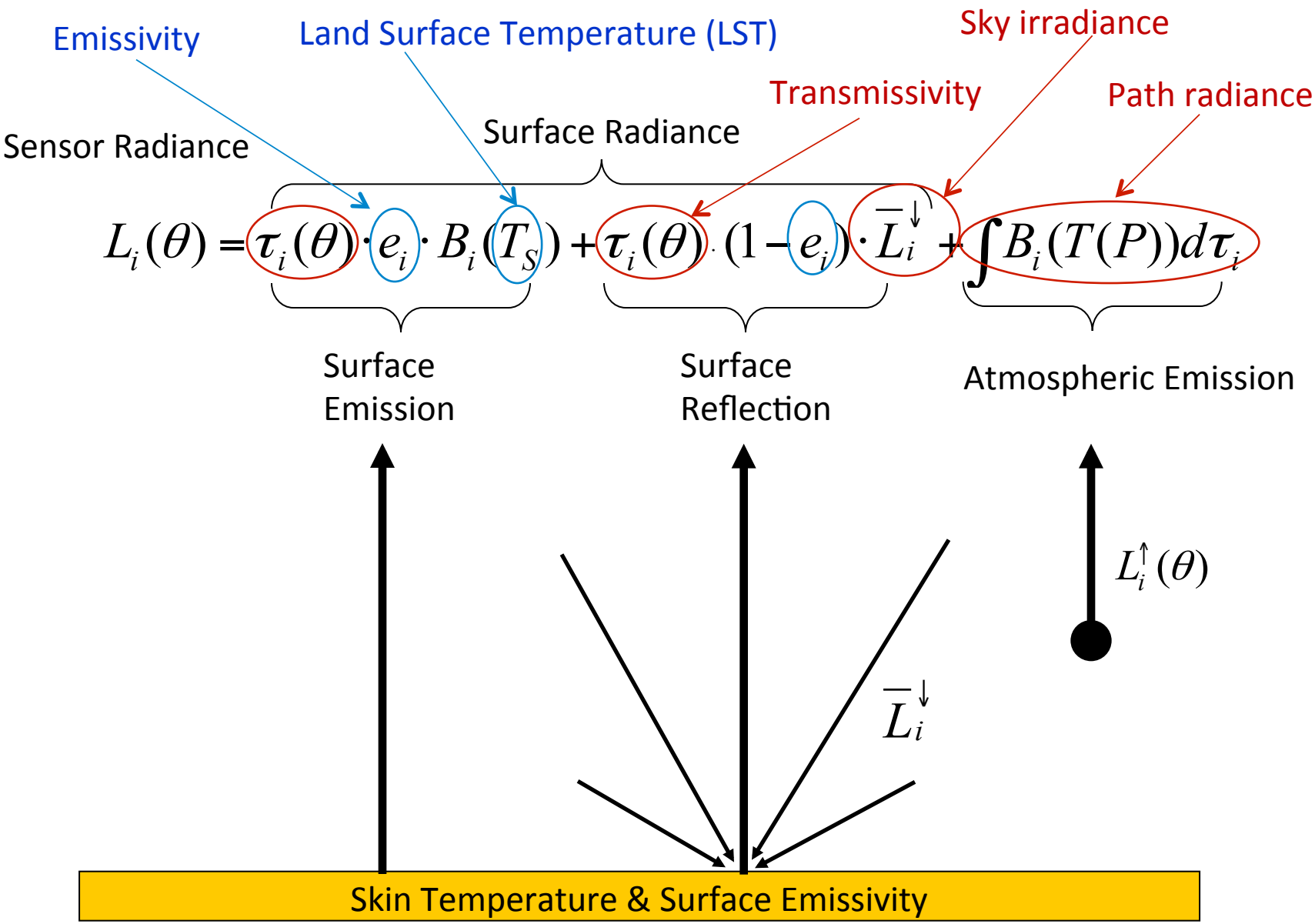
Swath Dimension: 5325 x 5325 pixels at 70m resolution (~400 x 400 km)
Filesize: 665 Mb

SDS	Long Name	Data type	Units	Valid Range	Fill Value	Scale Factor	Offset
LST	Land Surface Temperature	uint16	K	7500-65535	0	0.02	0.0
Emis1	Band 1 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis2	Band 2 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis3	Band 3 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis4	Band 4 emissivity	uint8	n/a	1-255	0	0.002	0.49
Emis5	Band 5 emissivity	uint8	n/a	1-255	0	0.002	0.49
EmisBB	Broadband Emissivity	uint8	n/a	1-255	0	0.002	0.49
Latitude	Pixel Latitude	float32	Deg	-90 to 90	999.99	n/a	n/a
Longitude	Pixel Longitude	float32	Deg	-180 to 180	999.99	n/a	n/a

e.g. LST = LST*0.02

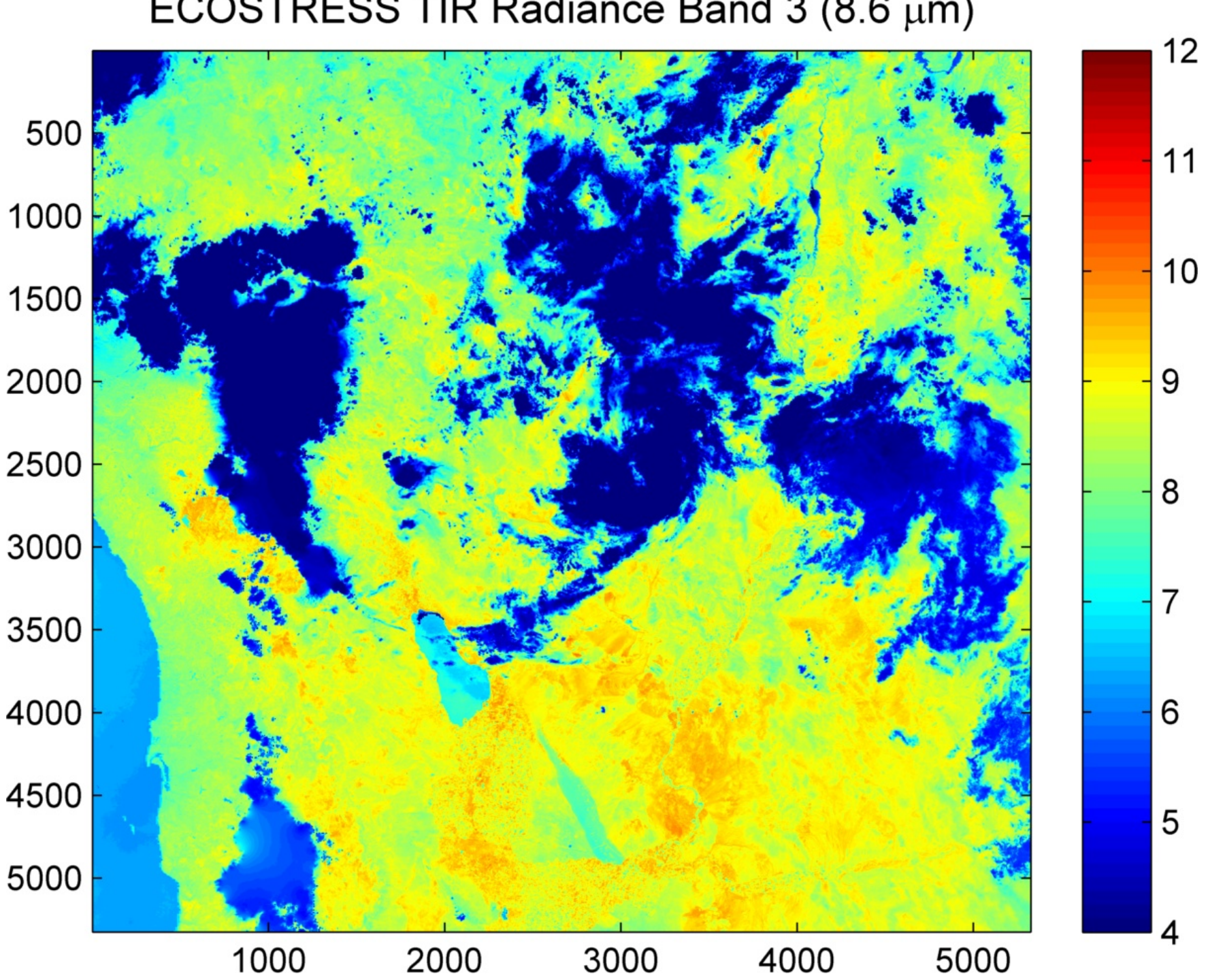
e.g. Emis1 = (Emis1 -0.49)*0.002

L1B Radiance Forward Modeling



L1B Radiance Simulation

- Use simulated ECOSTRESS L2 temperature/emissivity
- MERRA-2 atmospheric profiles and RTTOV model
- Forward calculate TOA radiances with RTTOV radiative transfer model
- Output in hdf5 ECOSTRESS format


ECOSTRESS TIR Radiance Band 3 (8.6 μm)
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
1000
2000
3000
4000
5000
12
11
10
9
8
7
6
5
4

Navigation

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NASA DEVELOP Project - Costa Rica Agriculture Summer 2016

Objective: To utilize simulated ECOSTRESS data products to estimate the changes in water stress in crops over a daily cycle using the Priestly-Taylor-JPL model and to evaluate the utility of future ECOSTRESS data streams for supporting agricultural water resources management.

Team: *Gregory Halverson, Mark Barker, Savannah Cooley, Steven Pestana (*indicates Team Lead)

Mentors: Dr. Christine Lee, Dr. Joshua Fisher

Partners at EARTH University: Dr. Johan Perret, Jose Eduardo Villalobos Leandro, Karim Abdalla Bolanos, Carol Lucia Fuentes Fallas

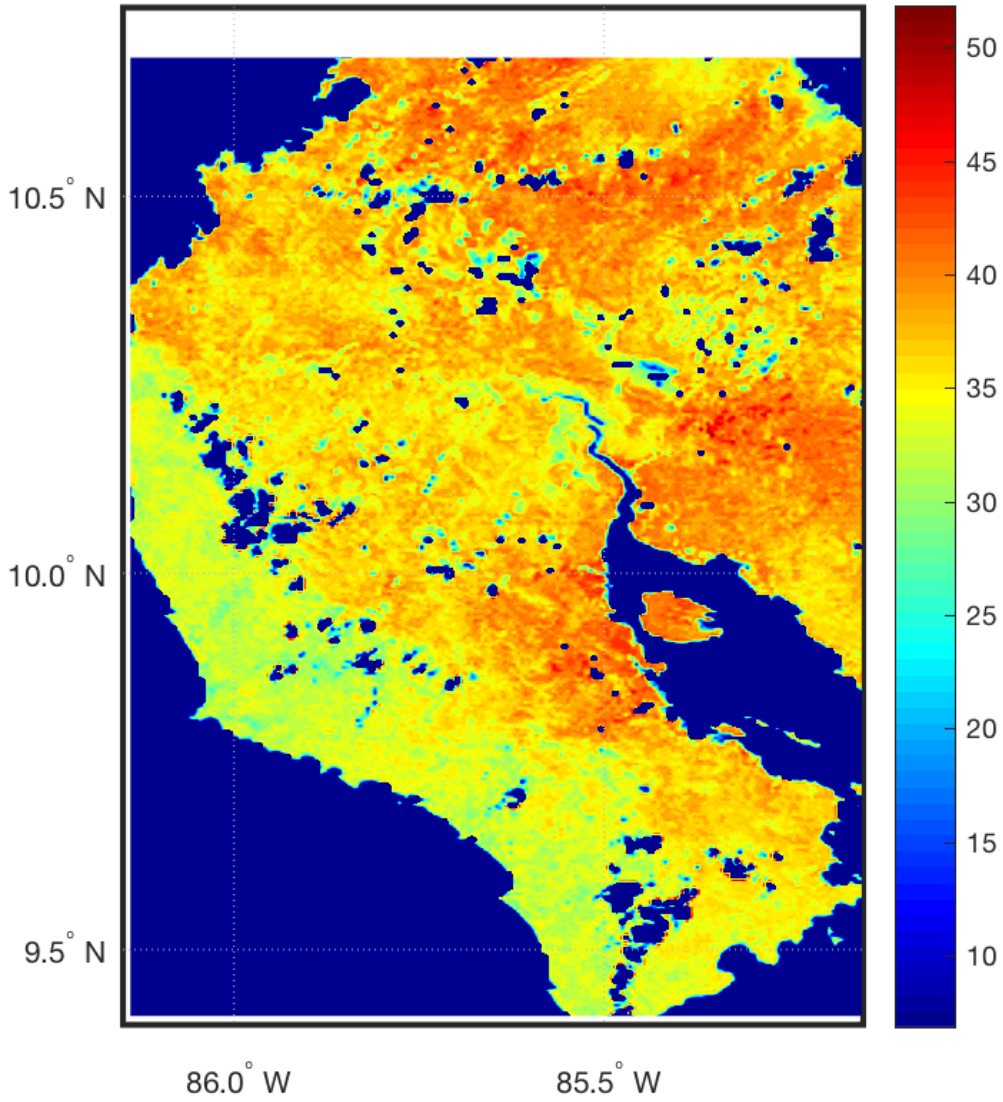
Upcoming Events

2016 HyspIRI Science and Applications Workshop
Oct 18, 2016 - Oct 20, 2016 — Pasadena, CA

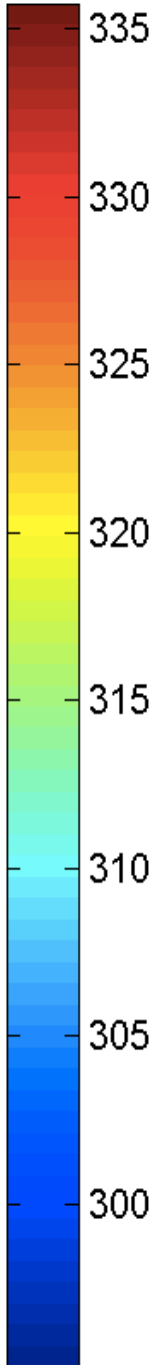
ECOSTRESS Science and Applications Team Meeting
Dec 06, 2016 - Dec 07, 2016

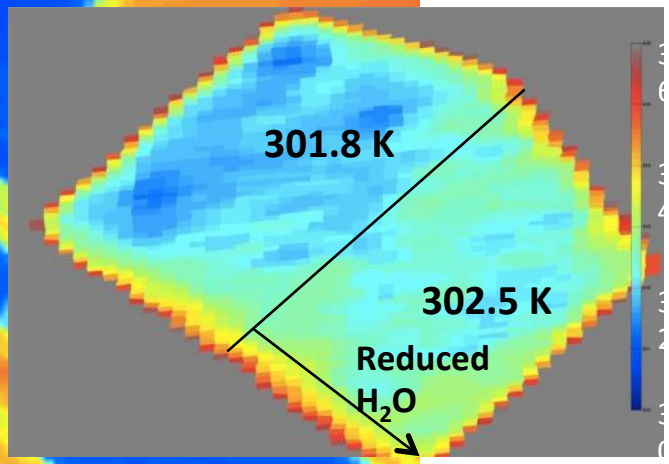
Upcoming events...

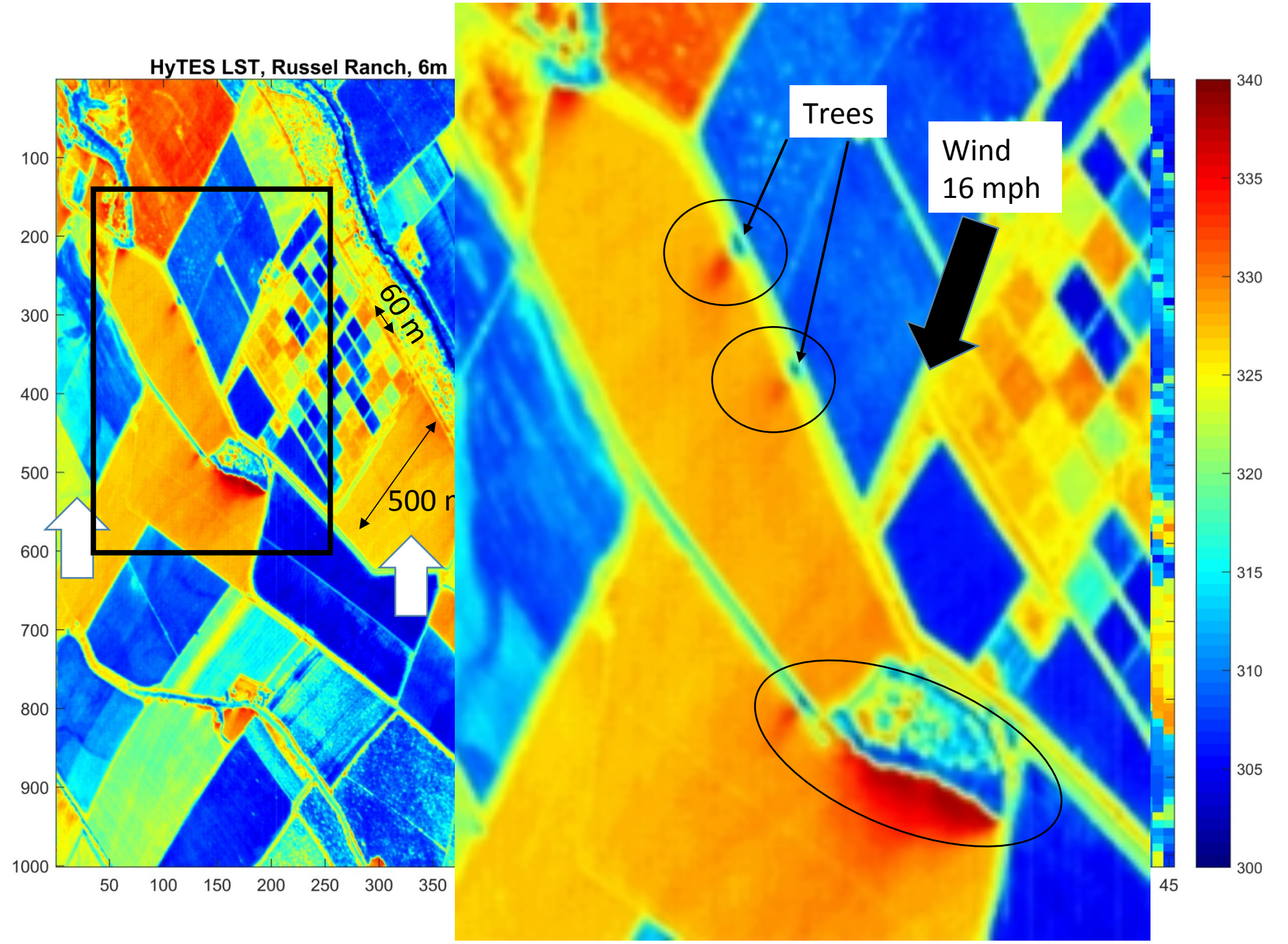
ECOSTRESS L2 Land Surface Temperature Simulated Image – Costa Rica
Generated by Steven Pestana

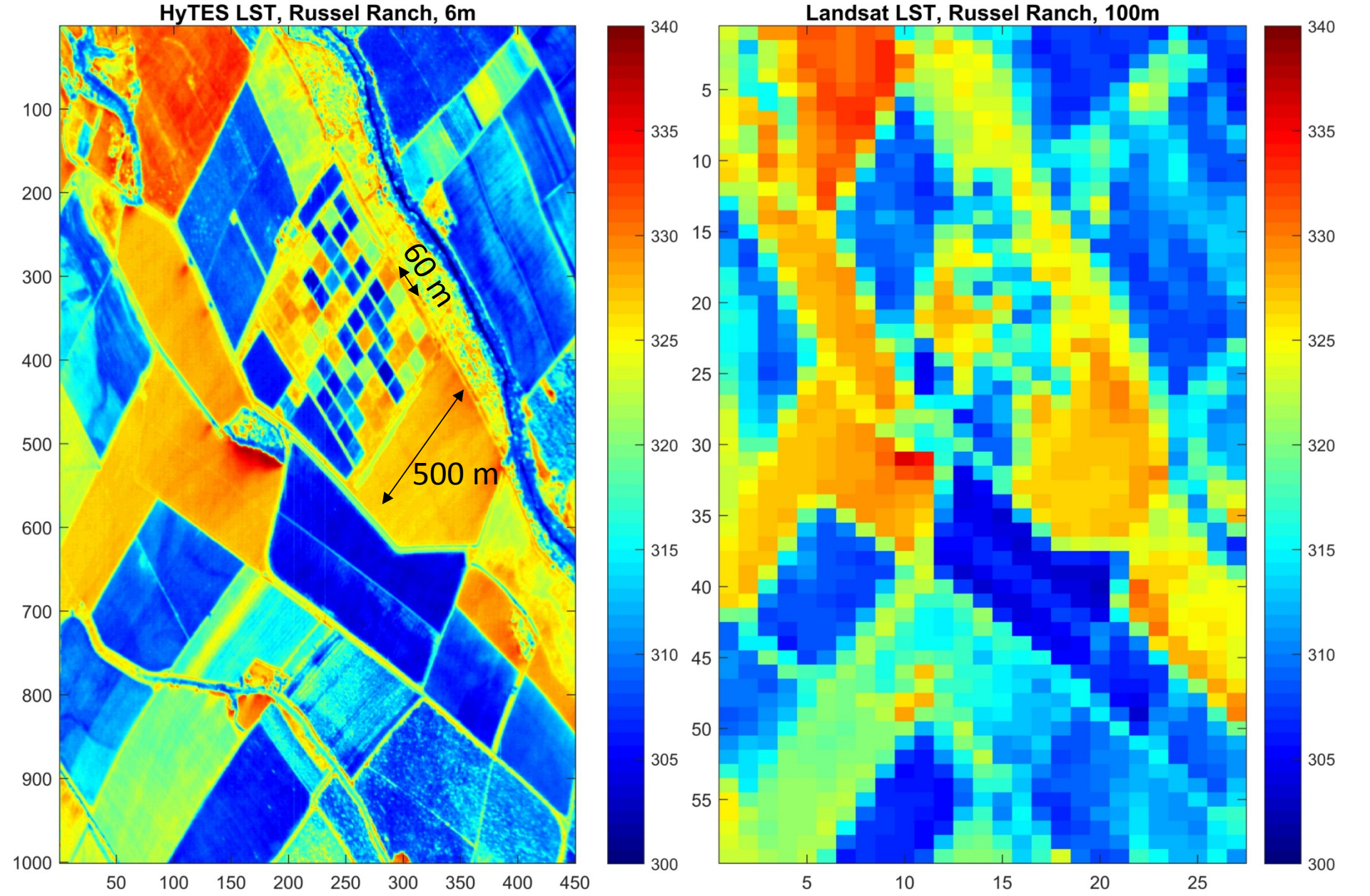


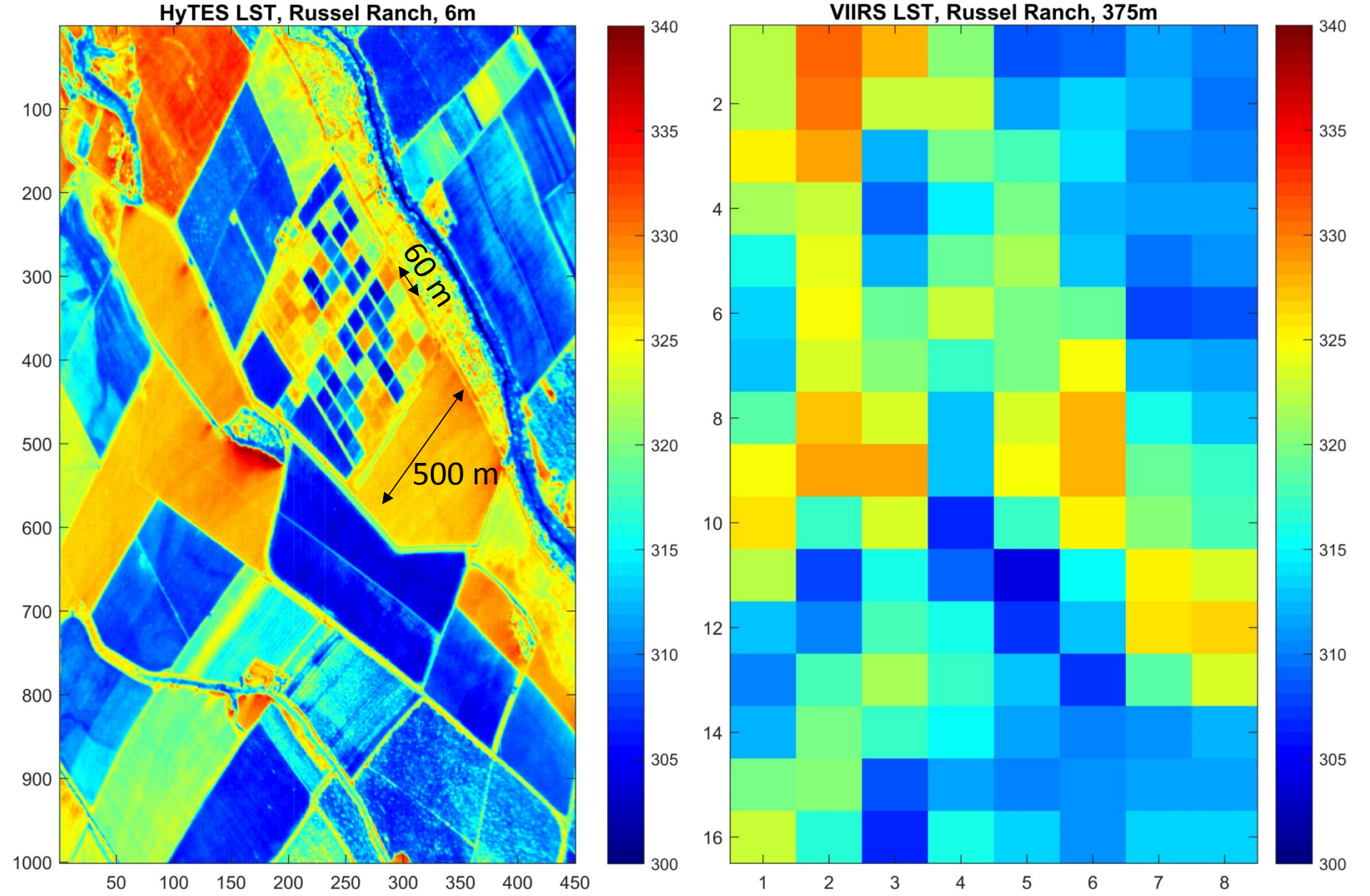
HyTES Acquisition: July 9, 2014

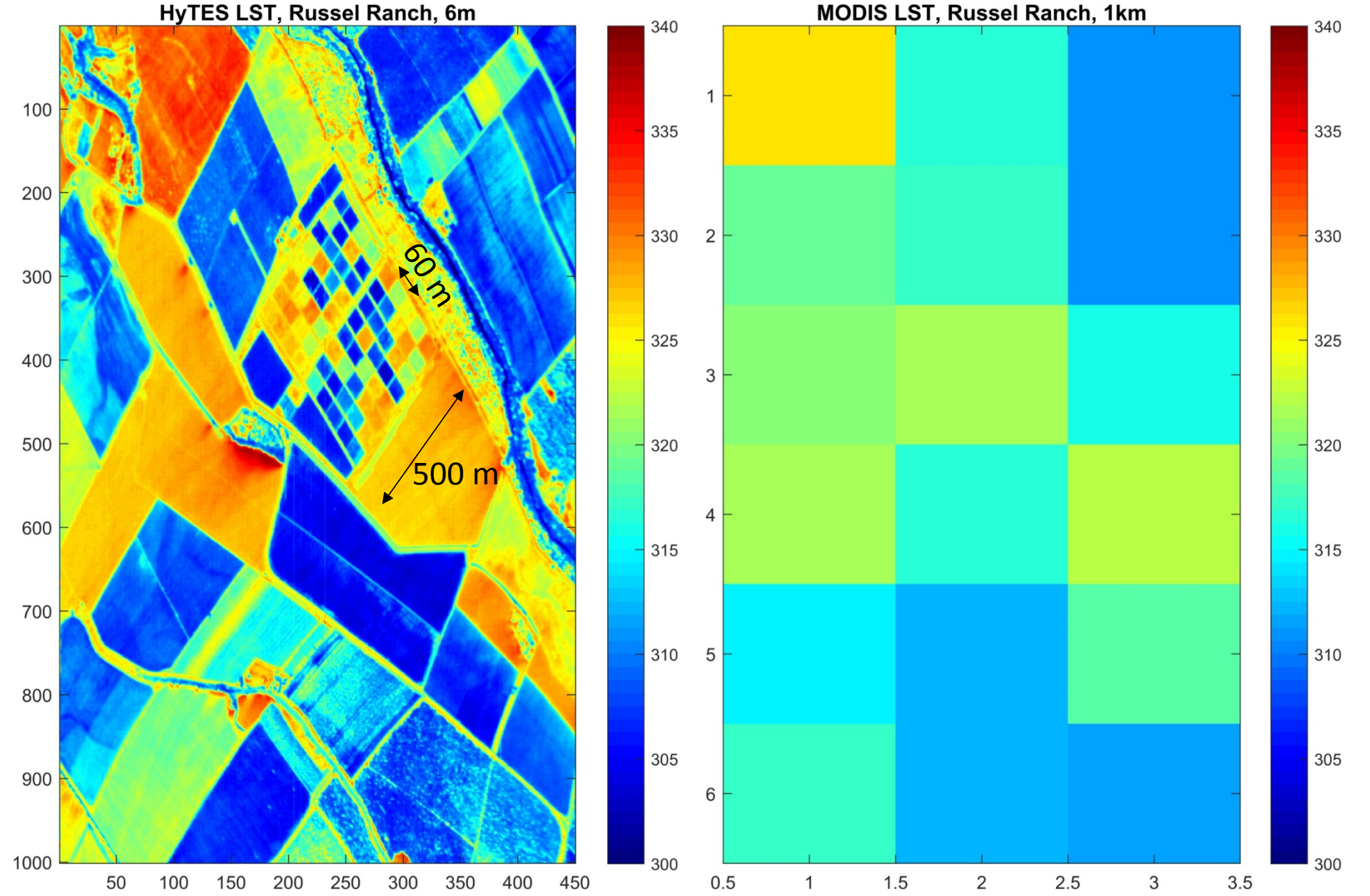


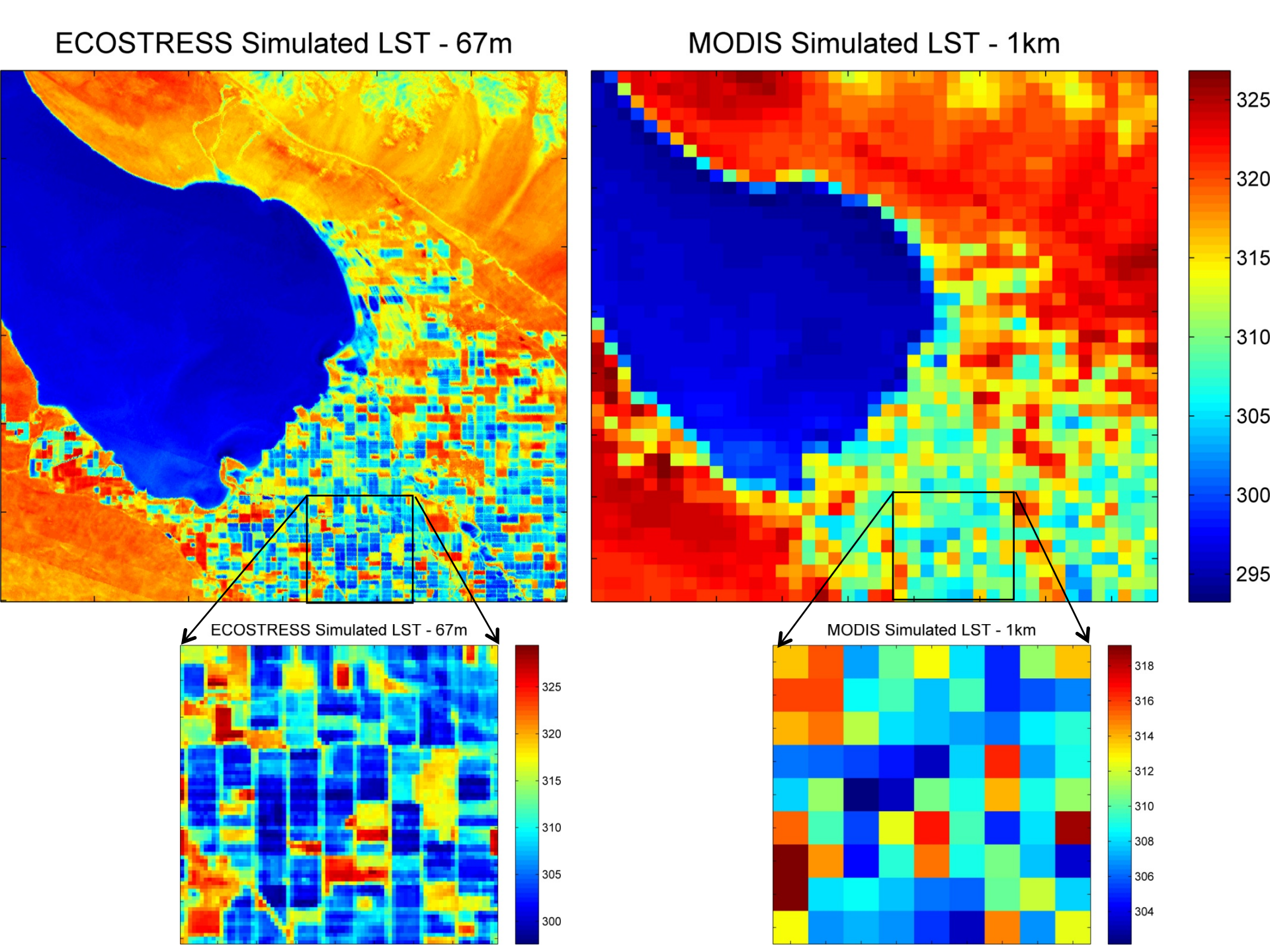



HyTES LST, Russel Ranch, 6m
100
200
300
400
500
600
700
800
900
1000
50
100
150
200
250
300
350
60 m
500 r
Trees
Wind
16 mph
45
340
335
330
325
320
315
310
305
300

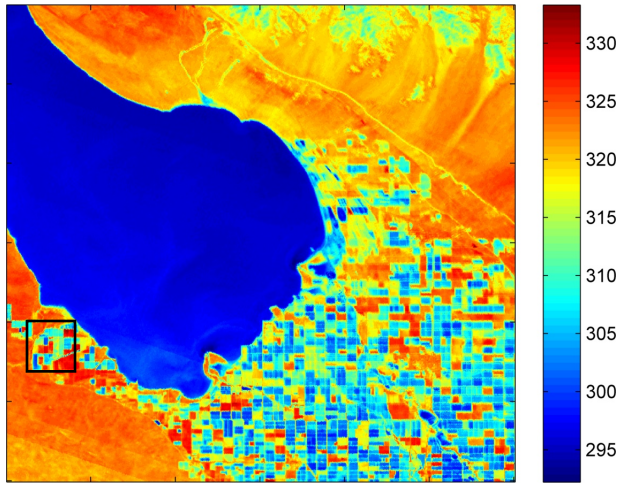

HyTES LST, Russel Ranch, 6m
60 m
500 m
100
200
300
400
500
600
700
800
900
1000
50
100
150
200
250
300
350
400
450
340
335
330
325
320
315
310
305
300
Landsat LST, Russel Ranch, 100m
5
10
15
20
25
30
35
40
45
50
55
5
10
15
20
25
340
335
330
325
320
315
310
305
300


HyTES LST, Russel Ranch, 6m
60 m
500 m
VIIRS LST, Russel Ranch, 375m


HyTES LST, Russel Ranch, 6m
60 m
500 m
100
200
300
400
500
600
700
800
900
1000
50
100
150
200
250
300
350
400
450
340
335
330
325
320
315
310
305
300
MODIS LST, Russel Ranch, 1km
1
2
3
4
5
6
0.5
1
1.5
2
2.5
3
3.5
340
335
330
325
320
315
310
305
300


ECOSTRESS Simulated LST - 67m
MODIS Simulated LST - 1km
325
320
315
310
305
300
295
ECOSTRESS Simulated LST - 67m
325
320
315
310
305
300
MODIS Simulated LST - 1km
318
316
314
312
310
308
306
304

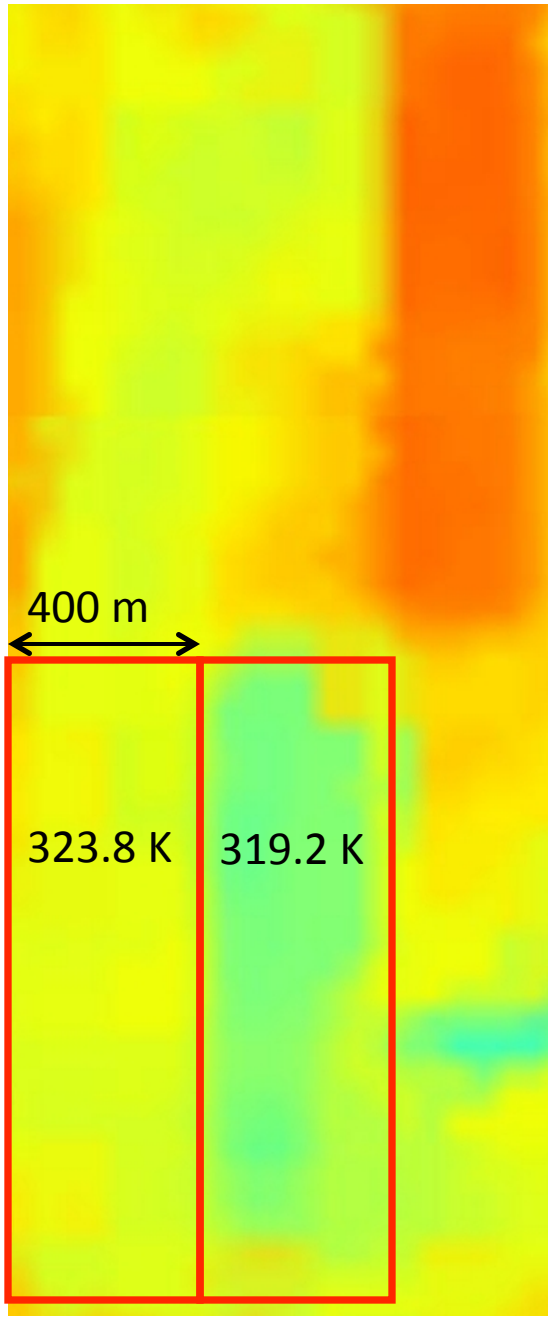
ECOSTRESS Simulated LST - 67m



1. **Signatures of vegetation stress are manifested in the LST signal *before* any visible deterioration of vegetation cover occurs.**

2. **The surface moisture state can be *deduced directly* from the remotely sensed LST.**

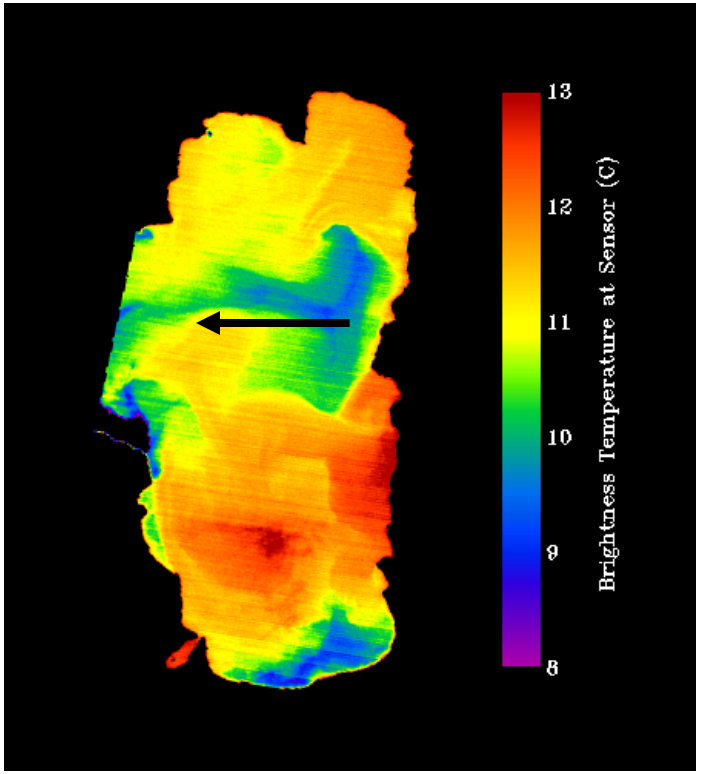
MASTER LST: 08/26/2014

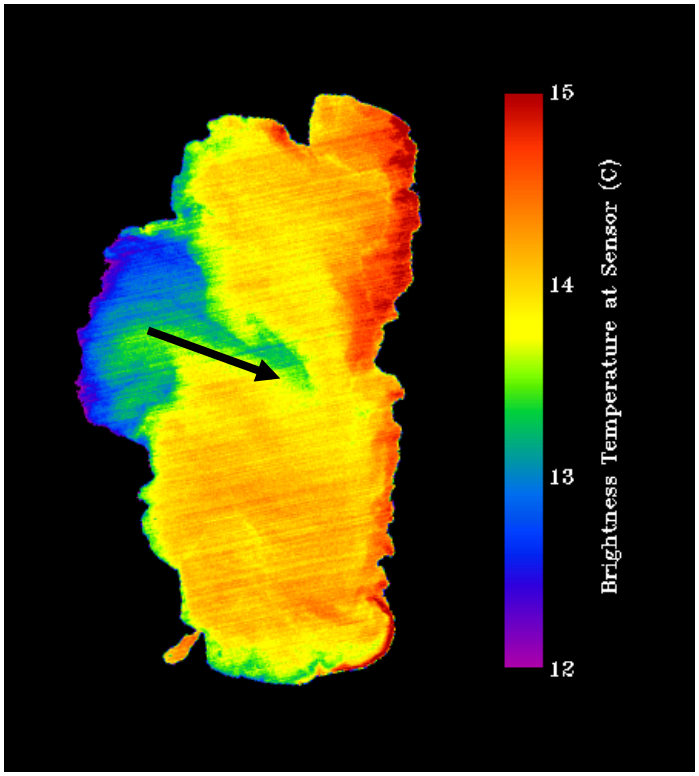


Google Earth: 08/28/14

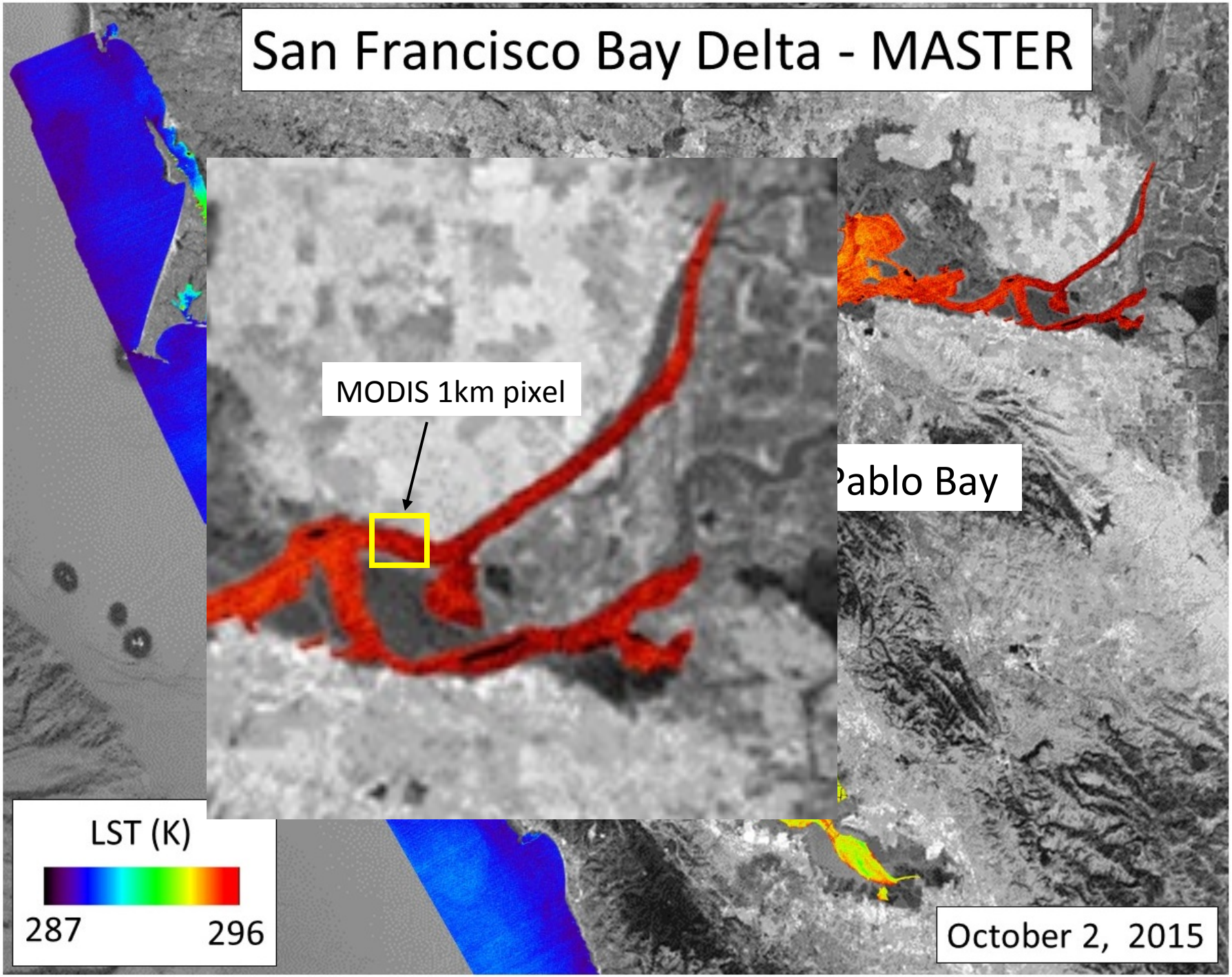
Temperatures of lacustrine systems

MASTER temperature of upwellings in Lake Tahoe, CA





- Wind induced
- Denser water at depth (10-30m) at upwind lake boundary
- Ecosystem functioning - facilitate phytoplankton growth
- Satellite/airborne imagery can tell us about frequency, distribution, water quality


San Francisco Bay Delta - MASTER
MODIS 1km pixel
Pablo Bay
LST (K)
287
296
October 2, 2015

LST Retrieval (single-channel)

1. Calculate Surface radiance

$$L_{s,i} = \epsilon_i B_i(T_s) + (1-\epsilon_i)L_i^{\downarrow} = \frac{L_i - L_i^{\uparrow}}{\tau_i},$$

2. Solve for surface emitted radiance

$$B_i(T_s) = \frac{1}{\epsilon_i}\left(\frac{L_i - L_i^{\uparrow}}{\tau_i} - (1-\epsilon_i)L_i^{\downarrow}\right) = L_{e,i}$$

$$B_\lambda = \frac{c_1}{\lambda^5\left[\exp\left(\frac{c_2}{\lambda T_s}\right)-1\right]}$$

3. Calculate LST by inverting Planck function: Ts = $B^{-1}(L_{e,i})$

$$T_s = \frac{c_2}{\lambda \cdot ln\left[\frac{c_1\epsilon}{\pi\lambda^5 L_{e,i}} + 1\right]}$$

c1, c2 = Planck constants